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Management Practices Followed for Maize Kernel against Aflatoxin Producing *Aspergillus flavus*

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The toxin production in maize is species specific and many factors play important role (Payne, 1992). Factors such as stress includes depletion of moisture content in the soil, elevated air temperature, longer night time, nutrient deficiency and other soil factors (Abbas *et al.*, 2002). Maize is photo insensitive crop cultivated in diverse environmental conditions *viz.*, extreme semi-arid to sub-humid and humid regions. In Indian subcontinent there is extreme diversity in soils and climatic conditions. Based on maize cultivation in different agro climatic conditions, country has been demarcated into five zones. Hence there is likely to exist variability in cob rot occurrence as well as aflatoxin contamination in the maize grains in India. Generally, at silking stage *A. flavus* invades and colonize to kernels and develop aflatoxins which persist till storage (Payne *et al.*, 1988). To refrain from the aflatoxin contamination in maize it has to begin at pre harvest stage and continued till storage which is considered as the best management practice.

Maize cob proteins

Resistance to maize against *A. flavus* and aflatoxin development is polygenic, quantitatively inherited trait and affected by environmental conditions (Naidoo *et al*, 2002). Maize kernel proteins which govern resistance to both abiotic and biotic stress, over a period of time, a series of proteomics detection methods used to identify resistance (Guo *et al.*, 1997) **(Table 1).**

Table 1 Maize cob protein associated with defense against *Aspergillus flavus*

Sl. No.	Antifungal/ Stress proteins	Characteristics/ function	Source	Detection method	References
1.	Ribosome-inactivating protein (RIP)	Inactivates foreign ribosome and protect against herbivores and pathogen	Endosperm (including aleurone layer) and embryo tissues	Immuno assay including western blot	Guo *et al.*, 1999
2.	Zeamatin	Increases permeability of fungal cell membrane, reduce fungal infection of the kernel during storage and germination	Endosperm (including aleurone layer) and embryo tissues	Immuno assay including western blot	Chen *et al.*, 1998

3.	14-kDa trypsin inhibitor (TI) protein	Spore rupture, abnormal hyphal growth of *Aspergillus flavus*, Inhibit *A. flavus* growth via inhibition of fungal α-amylase	Endosperm	Two-dimensional electrophoresis (2DE) and tandem mass spectrometry (MS/MS), Protein chromatography, SDS PAGE	Olga Pechanova and Tibor Pechan 2015
4.	Antifungal PR-10 protein	Inhibit *A. flavus* hyphal growth and conidial germination	Endosperm	Protein chromatography, SDS PAGE	Chen *et al.*, 2006
5.	Globulin 1 and 2, and late embryogenesis abundant proteins (LEA3, LEA 14)	Storage proteins	Kernel embryo and endosperm	Protein chromatography, SDS PAGE	Chen *et al.*, 2007
6.	Aldose reductase (ALD), osmotic stress-related proteins WSI18, peroxredoxin antioxidant (PER1), cold regulated protein, anionic peroxidase, glyoxalase I protein (GLX I) and several small heat shock proteins (HSP)	stress-related proteins	Kernel embryo and endosperm	two-dimensional electrophoresis (2DE) and tandem mass spectrometry (MS/MS), Protein chromatography, SDS PAGE	Chen *et al.*, 2004
7.	Chitinase A, PRm3 chitinase, and chitinase I	Silk defense protein	Maize silk portion	Protein chromatography, SDS PAGE	Peethambaran *et al.*, 2010
8.	HSPs (17.5 KDa, 22 KDa), remorin, ABA-responsive protein, chalcone-flavonone isomerase, caffeoyl-CoA 3-o methyltransferase, β-1,3-glucanase, PR-1, PR-5, Permatin, PAL, Asr protein, germin-like protein, abscisic stress ripening protein, auxin binding protein, class III acidic chitinase PRm3	Rachis defense protein	Rachis of maize cob	Two-dimensional electrophoresis (2DE) and tandem mass spectrometry (MS/MS), Protein chromatography, SDS PAGE	Pechanova *et al.*, 2013

Elimination of aflatoxins through pre-harvest and post-harvest methods

The best possible way of practice to eliminate aflatoxin from the food and feed is to begin from pre-harvest stage to post-harvest stage, during this time it inhibit the growth of the pathogen in the food commodities by drying method and maintain desirable percentage of moisture content in the food and feed materials, during the time of crop reaping maintain proper temperature and maintain hygiene in the field, these precautionary measures has to be taken during handling, processing and storing of the commodities before reaches to the consumers. The elimination process needs to be started right from the field level, so that impede the aflatoxin to cause cancer and other respiratory diseases in human and animals **(Table 2)**.

Table 2 Method employed for aflatoxin elimination

Sl. No.	Type of aflatoxin	Method	Features/characteristics	References
1.	Aflatoxins B1, B2, G1, and G2	Pre-harvest methods	Important practices such as good crop rotation, plantation and harvest of crops during the appropriate seasons	Aldred, 2004
2.	Aflatoxins B1, B2	Pre-harvest methods	Pesticides such as azoxystrobin and dinocap with a combination of sulphur found effective to decrease the level of aflatoxin	Tjamos *et al.*, 2004
3.	Aflatoxins B1, B2	Pre-harvest methods	biological control agent such as *Aspergillus niger* and *Bacillus subtilis* AF-1 found effective against aflatoxigenic *Aspergillus flavus*	Valero *et al.*, 2007
4.	Aflatoxins B1, B2	Pre-harvest methods	genetic engineering and bio-competitive exclusions techniques found effective in decreasing the levels of aflatoxins in plants such as cotton, peanuts and corn plants	Varga and Toth, 2005
5.	Aflatoxins B1, B2	Post-harvest methods	Judicious conditions for drying and storage, application of natural and chemical agents, aeration, and irradiation	Scudamore, 2005
6.	Aflatoxins B1, B2	Post-harvest methods	calcium propionate and potassium sorbate chemical preservatives effective against aflatoxigenic fungi	Arroyo *et al.*, 2005
7.	Aflatoxins B1, B2	Post-harvest methods	antioxidants such as 4- hydroxybenzoic acids and some plant oil extracts decreases aflatoxin level	Palumbo *et al.*, 2007
8.	Aflatoxins B1, B2, G1, and G2	Post-harvest methods	herbs and spices produces some phenolic compounds like flavonoids and coumarins against aflatoxins	Juglal *et al.*, 2002
9.	Aflatoxins B1, B2	Post-harvest methods	lactic acid bacterias used as biopreservatives by generating anti-microbial compounds like organic acids, acetic acids, H2O2 and cyclic dipeptides	Schnurer and Magnusson 2005
10.	Aflatoxins B1, B2, G1, and G2	Post-harvest methods	gases including CO, NO, SO2, and CO2 along with some modified atmospheres efficient to prevent aflatoxin producing *Aspergillus flavus* attack in stored grains	Cairns-Fuller *et al.*, 2005
11.	Aflatoxins B1, B2, G1, and G2	Post-harvest methods	irradiation is also acting to successfully destroy aflatoxin present in the liquid form of food	Kostecki *et al.*, 1991

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