DIAGNOSIS OF CONTAMINATION LEVELS OF WHITE MAIZE WITH AFLATOXIN IN COSTA RICA

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Abstract

This project was carried out by the Grain and Seed Research Center of the University of Costa Rica, with the collaboration of National Council for Production and economical support of the International Development Research Center of Canada.
Objectives were to determine aflatoxin levels of white maize throughout all stages of post-production systems and to determine the relationship between contamination and other factors such as climatic conditions, cultural practices, marketing and storage.
A total of 3009 samples were taken, within a two years period, from the four geographical zones of the country. Sampling was done since physiological maturity to final retails places or grain left for autoconsumption. Main analysis made were water content and aflatoxin contamination. Average aflatoxin content from all samples was 147 ng $^{-1}$g, varying between stages, geographical regions, and ways of grain handling. Contamination during pre-harvest was negligible but about 50% of samples taken short time after harvest (1 to 5 days), had 20 ng $^{-1}$g or more of total aflatoxin. Average aflatoxin content of samples of Brunca region was 275 ng $^{-1}$g while average of other zones was of 70 ng $^{-1}$g or less. About 65% of samples collected on the cob had less than 20 ng $^{-1}$g of aflatoxin but only 12% of samples shelled before picking up were not contaminated. There was not a direct relationship between water content at sampling time and contamination.

Introduction

Much have been mentioned about the importance of the problem of grain contamination with micotoxins during the pre and post-harvest stages. It is also true that one of the first steps to diminish the problem in any given place and time, is to evaluate the presence, frequency and levels of contamination, besides some other facts related to the specific situation. Based on previous experiences, there was enough evidence to suspect a serious problem of aflatoxin contamination in white maize in Costa Rica. Then, a good analysis of this situation was obviously needed to decide on the best actions to be taken to reduce the problem.

The two main objectives of this research project were:

1. To determine contamination levels in the most important maize producing regions and throughout all stages in the postharvest system.

2. To study the relationship between maize contamination levels and external factors such as climatic conditions, handling practices, storage and marketing.

The project was financially supported mainly by the International Development Research Center (IDRC) of Canada and the University of Costa Rica. Within UCR, the unit responsible for its execution was the Grain and Seed Research Center (CIGRAS). Very important support was received from de National Council for Production (CNP) of Costa Rica. The total duration of project was 3 years, from October 1985 to September 1988.

Materials and Methods

Sampling

According to economical resources, laboratory possibilities and availability of personnel and time, we decided to take about 3000 samples. Sample distribution by regions and stages in postharvest system was based on relative maize production and other considerations such as expected problems and degree of difficulty to obtain the samples.

Samples were taken from four geographic regions of the country named Brunca, Central, Chorotega and Huetar, and from the following eight stages in each region:

1. Before harvest (pre-harvest).
2. During harvest or very near after it.
3. During farm storage.
4. At arrival at CNP's buying agencies.
5. At arrival at CNP's silo plants.
6. Immediately after drying at CNP's silo plants.
7. During storage at CNP's silo plants.
8. In retail places (commerce).

Actual sample recollection was done in two ways. Most samples were taken directly by CIGRAS's personnel and some were first collected by CNP's personnel specially in the case of grain bought by this institution to farmers or after drying at CNP's facilities. In all cases minimum sample weigh was 5 kg. In samples of maize on the cob, enough cobs were taken to yield the 5 kg of grain.

Analysis

Main variables analyzed where: (a) aflatoxin, (b) water content, (c) visual mold damage and (d) fluorescence. Information about rainfall and temperature in sampling regions was also gathered.

Aflatoxin levels were estimated by Velascos's minicolumn method (Velasco, 1975) checking identification and levels by TLC (AOAC, 1970); water content was determined by oven method (AACC, 1969); mold damage by visual analysis and fluorescence by number of particles presenting this phenomenon in a broken kernel sample. Only selected results are presented here.

Results and discussion

Number of samples.

A total of 3009 samples were collected from all regions and grain handling system stages in the country (Table I). As reference, the average total annual production of white maize during this period was about 100.000 t.

Contamination levels.

Due to the methodology used in this work, the data mentioned about contamination should be taken just as an approximation to real levels and as an indication of the tendencies of contamination in the different sampling conditions.

The most generalized data found is the average of 147 ng $^{-1}$g of aflatoxin from all samples collected. This figure is very much affected by a contamination average of 275 ng $^{-1}$g in Brunca region while in all other regions average was 70 ng $^{-1}$g of aflatoxin or less (Table II).

Contamination is in general high. Only about half of all samples had less than 20 ng $^{-1}$g of aflatoxin and, even more, near 30% of the samples had levels of 100 or more ng $^{-1}$g.

In the pre-harvest stage, almost all samples had less than 20 ng $^{-1}$g of aflatoxin but, immediately after harvest, about 50% of the samples had more than 20 ng $^{-1}$g. This early contamination is present in all following stages such as in the grain left at the farm, at receiving points at CNP, during storage and in retail places (Table II).

Table I. Number and proportion of maize samples collected in Costa Rica, separated by region and handling stage.

STAGE	REGION								TOTAL	
	Brunca		Central		Chorotega		Huetar			
	Number --	%	Number --	%	Number --	%	Number --	%	Number --	%
Before harvest	22	(2)* 43 **	29	(5) 57	0	(0) 0	0	(0) 0	51	2
Right after harvest	187	(15) 46	20	(3) 5	94	(36) 23	105	(11) 26	406	13
Stored at farm	249	(20) 43	219	(38) 38	75	(29) 13	38	(4) 7	581	19
Arrival at CNP's buying station	362	(30) 41	0	(0) 0	52	(20) 6	476	(50) 53	890	30
Arrival at CNP's silo plant	81	(7) 59	0	(0) 0	0	(0) 0	57	(6) 41	138	5
After drying at CNP	123	(10) 34	0	(0) 0	0	(0) 0	240	(25) 66	363	12
During storage at CNP	20	(2) 30	46	(8) 70	0	(0) 0	0	(0) 0	66	2
Commerce	181	(15) 35	264	(46) 51	39	(15) 8	30	(3) 6	514	17
TOTAL PER REGION	1225		578		260		946		3009	
% OF TOTAL		(41)		(19)		(9)		(31)		100

* Percentage in relation to total per region.
** Percentage in relation to total per stage.

Table II. Average aflatoxin content in maize samples collected in Costa Rica, separated by region and handling stage.

STAGE	REGION				GENERAL LUG. ETAPA ng/g
	Brunca ng/g	Central ng/g	Chorotega ng/g	Huetar ng/g	
Before harvest	10 (22)**	0 (29)	nd * (0)	nd (0)	4 (51)
Right after harvest	270 (187)	26 (20)	65 (94)	40 (104)	151 (406)
Stored at farm	230 (249)	20 (219)	35 (75)	510 (38)	144 (581)
Arrival at CNP's buying station	380 (362)	nd (0)	35 (52)	65 (476)	191 (890)
Arrival at CNP's silo plant	200 (81)	nd (0)	nd (0)	20 (57)	126 (138)
After drying at CNP	165 (123)	nd (0)	nd (0)	30 (240)	76 (363)
During storage at CNP	185 (20)	45 (46)	nd (0)	nd (0)	87 (66)
Commerce	376 (181)	14 (264)	12 (39)	15 (30)	141 (514)
AVERAGE PER REGION	289 (1225)	18 (578)	42 (260)	67 (946)	146 (3009)
AVERAGE PER REGION EXCLUDING COMMERCE	274 (1044)	22 (314)	48 (221)	69 (916)	147 (2495)

* No samples taken.
** Total number of samples.

Contamination and environmental conditions.

As known, fungi growth is directly related to moisture content and temperature of the substrate were they grow . Therefore, environmental conditions are necessarily going to affect fungi growth, depending on the effect the environment can really have on temperature and moisture of the substrate. Because of this indirect effect of the environment with mold growth, it is very difficult to relate it with mycotoxin contamination in a field work as the present one.

In our case, the situation is that Brunca and Huetar regions have a very high rainfall, nearly 4 m per year, while in other regions rainfall is lower (1500 mm in Chorotega region and 2000 in the Central one) and with better defined dry and wet seasons (Fig. 1). Ambient average temperature is always over 21 °C everywhere which is high enough to allow *Aspergillus flavus* and *A. restrictus* growth, being of course substrate temperatures even higher because of grain and fungi metabolism. According to our results, environmental conditions did not have a predominant effect on aflatoxin contamination . The best reason to arrive to this conclusion is that in fact, as mentioned before, contamination was much higher in Brunca than Huetar region, having both, as mentioned, similar temperature and rainfall levels.

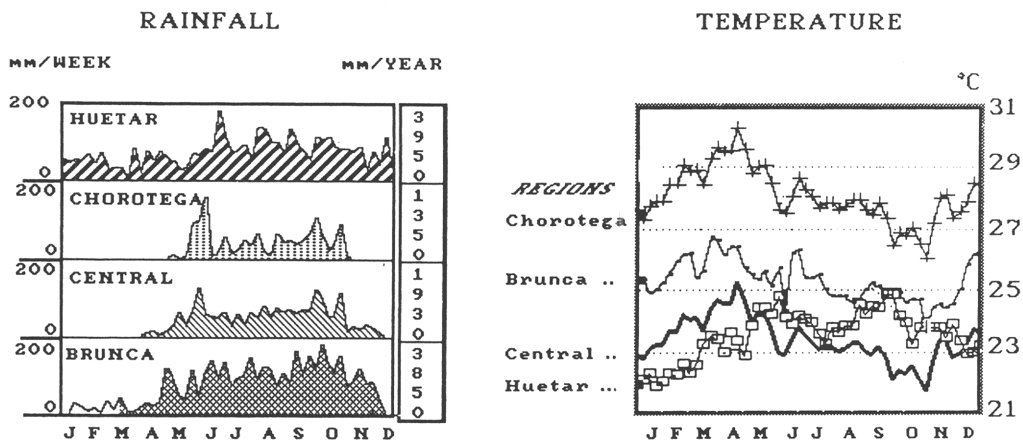
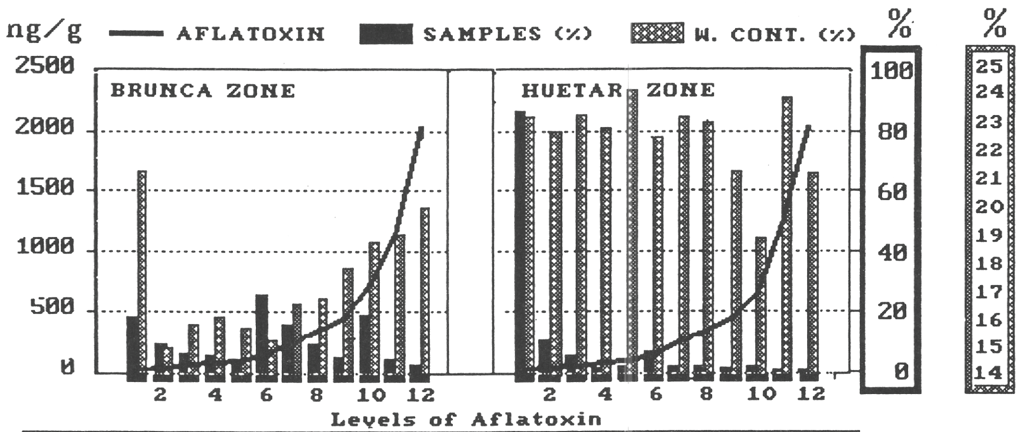


Figure 1. Rainfall and temperature anual variation in different regions of Costa Rica

Contamination and water content.

The effect of grain moisture levels on contamination is dependent of many other factors such as temperature, grain variety, kernel soundness, inoculum, exposure time, etc. In this case, we just considered the relationship between contamination levels and grain water content at sampling time.

In general, samples with higher water content at sampling time had lower aflatoxin levels. Samples from Huetar region had higher water content than those from Brunca region but had less contamination (Fig. 2). Evidently this situation is due to other reason besides moisture levels, for instance, differences in handling as presented below.



1 = <20	4 = 60-79	7 = 200-299	10 = 500-999
2 = 20-39	5 = 80-99	8 = 300-399	11 = 1000-1499
3 = 40-59	6 = 100-199	9 = 400-499	12 = >1500

Figure 2. Water content, at sampling time, and aflatoxin in maize from Brunca and Huetar zones in Costa Rica.

Contamination and maize handling.

In Huetar region, most maize is sold to CNP and it is received on the cob. It is threshed at CNP facilities right before drying. On the contrary, in Brunca region, maize is threshed at the farm and, since farmers do not have dryers, this is done by sun-drying or later at CNP's silo plants.

Average contamination level of samples of maize collected already threshed is much higher that level of aflatoxin in samples obtained on the cob. Nearly 65% of samples received on the cob had less than 20 ng $^{-1}$g of aflatoxin versus only 12% of those received already threshed. This relationship between the way grain is handled and the contamination level is independent of the region where the samples were collected. In Brunca region samples were collected in both forms, having an average of 335 ng $^{-1}$g of aflatoxin in those collected already threshed and of 54 ng $^{-1}$g in those collected on the cob.

Conclusions

We consider that maize contamination in Costa Rica is very high and all possible efforts to diminish it should be made. Some actions already underway to face this problem are the establishment, upon realistic bases, of permissible levels of contamination of maize; better quality controls at CNP's grain receiving places; the conduction of test to evaluate the possibility of CNP to receive maize on the cob in Brunca region, where the problem is worse; follow up studies at CIGRAS to learn more about the dynamic of contamination and possible alternatives for better handling of the grain. Plans for future extension programs on this subject have already been considered.

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NIVEAUX DE CONTAMINATION DU MAIS BLANC PAR L'AFLOTAXINE AU COSTA RICA

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RESUME

Ce projet a été mené par le Centre de Recherche sur les semences et les graines de l'Université du Costa Rica, en collaboration avec le Conseil National de la production et l'aide économique du Centre de la Recherche et du développement International du Canada.

Les objectifs étaient le calcul des taux d'aflatoxine du maïs blanc à toutes les étapes post-récolte et la mesure des relations entre la contamination et d'autres facteurs comme les conditions climatiques, les pratiques culturales, le circuit commercial et le stockage.

Un total de 3.000 échantillons a été collecté au cours d'une période de deux années, dans les quatre zones géographiques du pays. L'échantillonnage a été entrepris depuis la maturité physiologique jusqu'à la zone finale de stockage, ou jusqu'aux grains laissés sur place pour la consommation locale. Les principales analyses réalisées ont porté sur le degré d'humidité, mesuré à l'étuve, et la mesure d'aflatoxines par minicolonne (la méthode Velasco) puis confirmation par chromatographie en couche mince (CCM).

Pour l'ensemble des échantillons, la teneur moyenne en aflatoxines était de 155 ng/g mais variait suivant les étapes, les régions géographiques et les différentes façons de manipuler les grains. La contamination avant récolte était négligeable, cependant, près de 50 % des échantillons de la partie sud du pays avaient 275 ng/g, ou moins. Près de 65 % des échantillons collectés sur l'épi avaient moins de 20 ng/g d'aflatoxine mais seulement 12 % des échantillons encore dans leur gousse avant le ramassage, n'étaient pas contaminés.