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REPUBLIC OF SOUTH AFRICA

Science transforming food systems for a better future

Integrated mycotoxin management systems

Dr. B. Janse van Rensburg

BelindaJ@arc.agric.za

ARC-GC Mycotoxin research team

Dr. B.C. Flett - Resistance, screening, breeding, management practices (CA/conventional)
Dr. B. Janse van Rensburg - Epidemiology, stressors, fungicides, management practices (CA/conventional)
Dr. A. Schoeman - Isolate variation and interactions, molecular, FGSC, etiology
Dr. E. Ncube - Bt technology, stem borers, subsistence farmers, storage facilities

Collaborators:
Stellenbosch University, Free State University, North-West University, ARC-PPRI, ARC-OVI, PANNAR Seed Company, Cape Peninsula University of Technology, South African Sugar Research Institute, South African Grain Laboratories, University of Nairobi, Kenya, CIMMYT, Kenya, Partnership for Aflatoxin Control in Africa, Ethiopia, IITA, Nigeria and various individuals and institutions from Europe and the USA.

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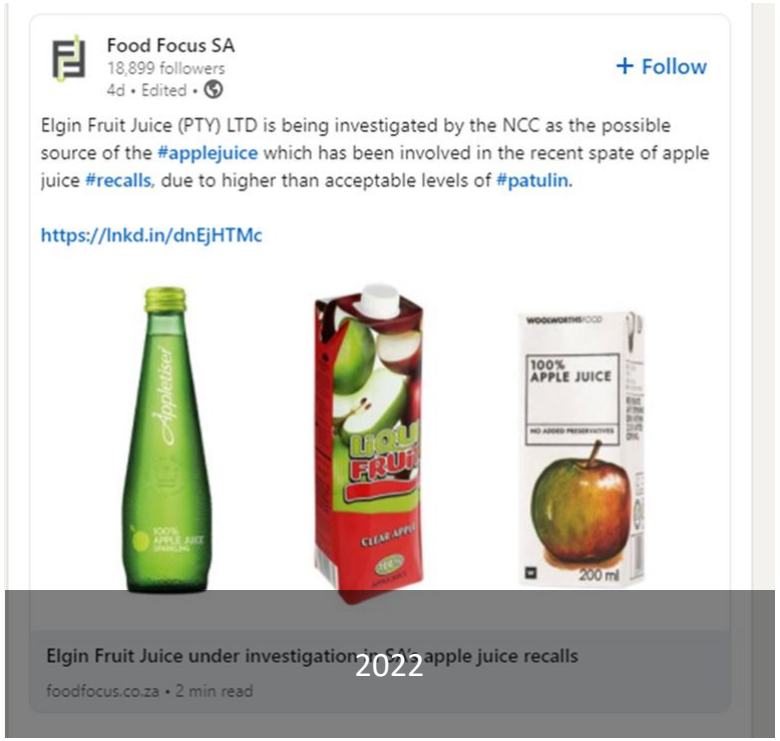
31 May 2023



2022

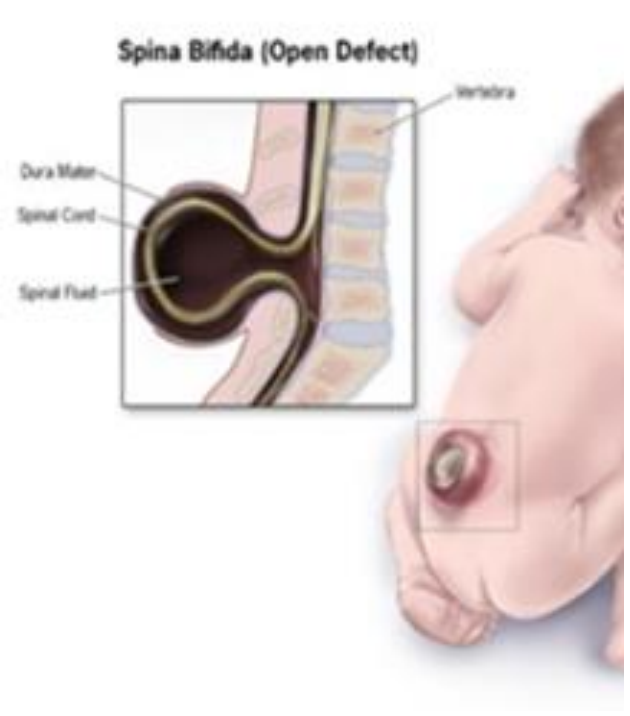
What is a mycotoxin?

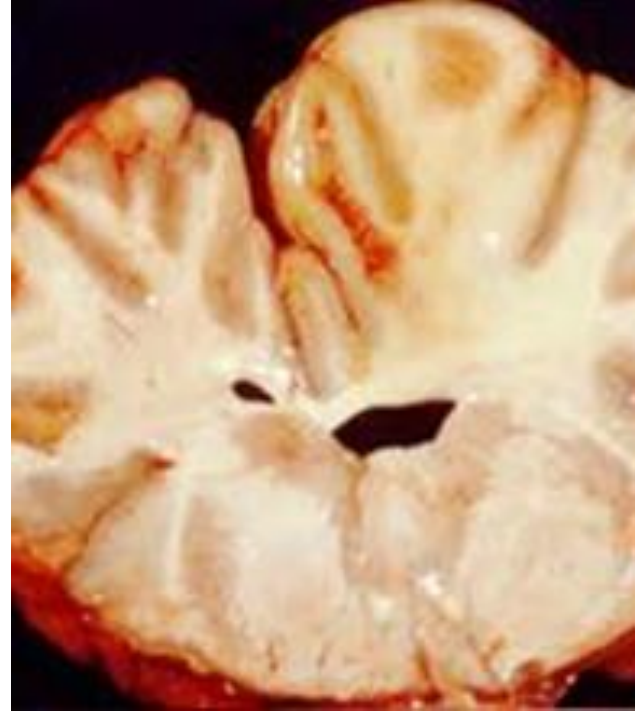
- Secondary metabolites produced by certain fungi
- Pre-harvest (*Fusarium spp., Stenocarpella maydis* and *Aspergillus spp.*)
- Post-harvest (*Aspergillus spp.* and *Penicillium spp.*)

- Regulation in SA exist for Patulin, Aflatoxin, Fumonisin and Deoxynivalenol

- Regulatory infrastructure and expertise not always available, making inspection and regulatory control in Africa difficult

Mycotoxin group	**Commodity affected**	**Producing fungus**	Mycotoxins
Aflatoxins	Maize, peanuts, sorghum, soya,	*Aspergillus flavus* *Aspergillus parasiticus*	AFB_1, AFB_2
Trichothecenes	Maize, wheat, barley, sorghum, soya, oats	*Fusarium graminearum* species complex	DON, NIV
Zearalenone	Maize, wheat, barley, sorghum, silage	*Fusarium graminearum* species complex	ZEA
Fumonisins	Maize, sorghum	*Fusarium verticillioides* *Fusarium proliferatum*	FB_1, FB_2 , FB_3





Why manage mycotoxigenic fungi and mycotoxins?

- Affect the entire food and feed production chain
- Reduction of marketable grain
- Increased cost of drying
- Decreased weight gain in animals
- Negative impact on animal and human health
- Restrict markets (developing countries)

Integrated management options – pre harvest

- Cultural
- Biological
- Resistance
- Chemical

Rose, L.J., Okoth, S., Flett, B.C., Janse van Rensburg, B. and Viljoen, A. 2019. Preharvest Management strategies in their impact on mycotoxigenic fungi and associated mycotoxins. In: Mycotoxins: Impact and Management Strategies (P. Njobeh and F. Stepman). Intechopen, DOI: 10.5772/intechopen.72353

Cultural control

- Minimize plant stressors
  - -Planting dates
  - -Plant densities
  - -Optimum use of fertilisers

Plant density/ cultivar	10 000 plants/ha	20 000 plants/ha	30 000 plants/ha	40 000 plants/ha	50 000 plants/ha	
	fumonisins	fumonisins	fumonisins	fumonisins	fumonisins	Mean
PAN6P-110	1.47	2.79	3.20	3.66	16.65	5.55
CRN3505	0.49	2.93	3.11	3.83	2.40	2.55
Mean	0.98	2.86	3.15	3.75	9.53	

Plant density x cv interaction regarding fumonisin (P=0.04)

Cultural control

- Minimize plant stressors
  - -Weeds
  - -Plant Pathogens
  - -Stalkborers

E. Ncube, B. C. Flett, J. Van den Berg, A. Erasmus, A. Viljoen. 2017. The effect of *Busseola fusca* infestation, fungal inoculation and mechanical wounding on Fusarium ear rot development and fumonisin production in maize. Crop Protection 177-183.

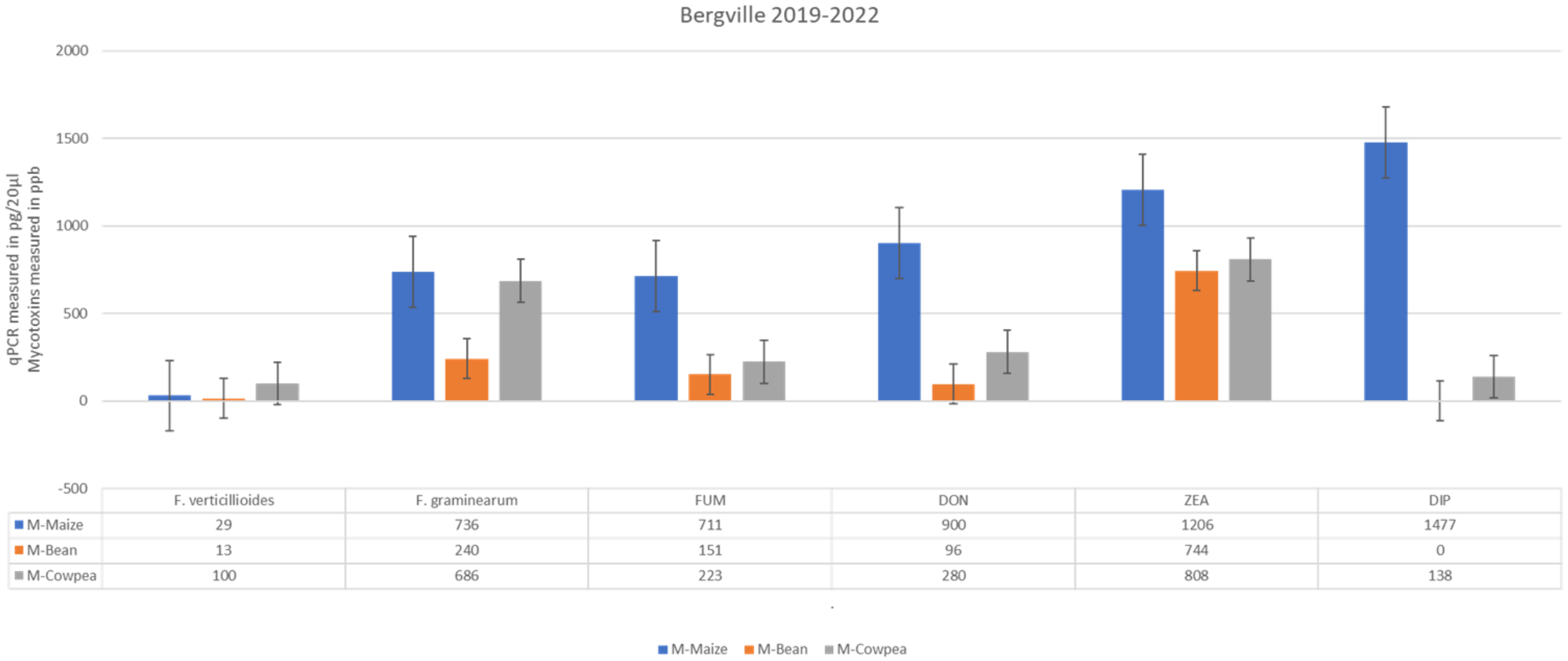
Craven M, Morey L, Abrahams A, Njom HA, Janse van Rensburg B. (2020). Effect of northern corn leaf blight severity on Fusarium ear rot incidence of maize. South African Journal of Science 16, 11-12.

Cultural control

- Cultivation practices
  - -Tillage practices
  - -Crop rotation
  - -Intercropping

Flett, B. C., McLaren, N. W., and Wehner, F. C. 2001. Incidence of *Stenocarpella maydis* ear rot of corn under crop rotation systems. Plant Dis. 85:92-94.

Londiwe M. Mabuza & Belinda Janse van Rensburg &Bradley C. Flett & Lindy J. Rose. (2018). Accumulation of toxigenic *Fusarium* species and *Stenocarpella maydis* in maize grain grown under different cropping systems. European Journal of Plant Pathology. https://doi.org/10.1007/s10658-018-1475-y.



	F. verticillioides	F. graminearum	FUM	DON	ZEA	DIP
M-Maize	29	736	711	900	1206	1477
M-Bean	13	240	151	96	744	0
M-Cowpea	100	686	223	280	808	138

B. Janse van Rensburg *et al*. The impact of conservation agriculture on maize ear rots and resultant mycotoxin production in commercial and smallholder farming systems (P05000126).

B.C. Flett *et al*. Severity and incidence of *Stenocarpella maydis* ear and stalk rots in South Africa and the variation in *S. maydis* isolates, collected from maize stalks and kernels in their production of Diplodiatoxin and toxicity reactions on ducklings.

Biological control

Biological control agent modes of action are antibiosis, competition, mycoparasitism, and stimulation of plant defense.

- Aflasafe is based on the ecological principle of “competitive exclusion” or the idea that when two species compete for the same critical resources within an environment, one of them will eventually outcompete and displace the other.
- Non aflatoxigenic strains will outcompete toxigenic aflatoxin levels.

Flett B.C., Njom, H. Janse van Rensburg. New proposal submitted to DALRRD. Control of aflatoxins on groundnuts using non-aflatoxigenic isolates.

Host Plant Resistance

- Cultivars have tolerance, but not resistance against mycotoxigenic fungi
- Polygenic, quantitative
- Environment is one of the main variables driving infection and mycotoxin production

Janse van Rensburg, B., McLaren, N.W. and Flett, B.C. 2017. Grain colonization by fumonisin-producing *Fusarium* spp. and fumonisin synthesis in South African commercial maize in relation to prevailing weather conditions. Crop Protection 102: 129-136.

N. E. I. Netshifhefhe . B. C. Flett . A. Viljoen . L. J. Rose. (2018). Inheritance and genotype by environment analyses of resistance to *Fusarium verticillioides* and fumonisin contamination in maize F1 hybrids. Euphytica 214:235

S. Links, K. van Zyl, A. Cassiem, B.C. Flett, A. Viljoen and L.J. Rose. (2020). The association of maize characteristics with resistance to *Fusarium verticillioides* and fumonisin accumulation in commercial maize cultivars. World Mycotoxin Journal. DOI 10.3920/WMJ2019.2537

Chemical control

- Plant phenology
  - -Maize (husk)
  - -Wheat
- No registered fungicides for *F. verticillioides* or *A. flavus* in any African country

Table 5
The effect of environment and fungicide treatment (T1 = unsprayed, T2 = sprayed) × cultivar interactions on total fumonisin (expressed in ppm) in maize kernels for the 2011 and 2012 seasons combined. Bold values indicate main effects for cultivars, seasons and localities.

Locality/cultivar/season	Makhatini			Potchefstroom			Buffelsvlei			Vaalharts			Greytown			Cedara			Mean T1	Mean T2
	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean		
PAN6611	17.99	22.19	**20.09**	1.43	1.21	**1.32**	0.19	5.02	**2.61**	7.63	6.92	**7.28**	13.76	13.57	**13.67**	1.64	3.06	**2.36**	7.11	8.66
LS8521B	6.92	9.86	**8.40**	4.41	25.16	**14.79**	0.46	0.32	**0.39**	5.15	7.16	**6.16**	5.80	11.29	**8.55**	1.29	1.25	**1.27**	4.01	9.17
PAN6P-110	26.59	35.38	**30.99**	11.05	7.63	**9.35**	1.98	3.83	**2.91**	10.34	12.21	**11.28**	23.33	18.02	**20.68**	2.80	0.43	**1.62**	12.68	12.92
DKC80-10	32.53	42.48	**37.51**	0.39	6.96	**3.54**	0.37	2.17	**1.28**	11.27	15.96	**13.62**	8.35	9.57	**8.97**	5.24	2.37	**3.80**	9.69	13.25
DKC80-12B	16.57	13.70	**15.14**	0.25	0.31	**0.29**	0.52	0.37	**0.45**	16.74	16.93	**16.84**	6.58	16.81	**11.70**	2.28	2.41	**2.35**	7.16	8.42
DKC78-15B	15.47	5.60	**10.54**	0.32	0.65	**0.49**	0.15	2.02	**1.09**	12.23	17.03	**14.63**	8.94	11	**9.97**	1.52	2.41	**1.97**	6.44	6.45
CRN3505	25.94	59.50	**42.72**	0.79	4.07	**2.44**	2.71	0.86	**1.79**	14.71	16.66	**15.69**	17.12	20.77	**18.95**	4.74	0.55	**2.65**	11.00	17.07
Mean	**20.28**	**26.96**		**2.66**	**6.57**		**0.91**	**2.08**		**11.52**	**13.27**		**11.87**	**11.66**		**2.78**	**1.78**		**8.30**	**10.85**

*Indicates significant differences (LSD $P < 0.05$).
*LSD = 4.823 (Environment).
*LSD = 1.414 (Treatment).
*LSD = 2.994 (Cultivars).
Limit of detection = 0.016 ppm.

Janse van Rensburg, B., McLaren N.W., Schoeman, A. and Flett, B.C. 2016. The effects of cultivar and prophylactic fungicide spray for leaf diseases on colonisation of maize ears by fumonisin producing *Fusarium* spp. and fumonisin synthesis in South Africa. Crop Protection 79: 56-63.

Discussion

Commercial production

- Consumption of a more varied diet with a lower average consumption of cereal grains
- Improved standards of crop management and storage
- Public education, extensive surveillance and stringent regulation

Subsistence / small holder production

- Often rely on staple foods affected by mycotoxins
- Missing legislation and poor surveillance programs
- Lack of adequate resources for mycotoxin control
- Planting of seed from previous season's crop
- Unable to purchase fertilizers and insecticides, poor storage
- Absence of information on mycotoxins and their control

Discussion

- Research (including risk assessment)
  - -National and international
  - -Funding
  - -Capacity building
- Risk management (including regulation)
  - Improved collaboration
  - Affordable management strategies
- Mitigation (including risk communication)

Yun Yun Gong, Belinda Janse van Rensburg, Martin Kimanya and Hans P. van Egmond. 2018. Foreword: World Mycotoxin Journal Special Issue – Mycotoxins in Africa. World Mycotoxin Journal, 2018; 11 (3): 305-309

Thank you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