An empirical analysis of explanatory variables affecting *Fusarium* and deoxynivalenol in wheat for feed production

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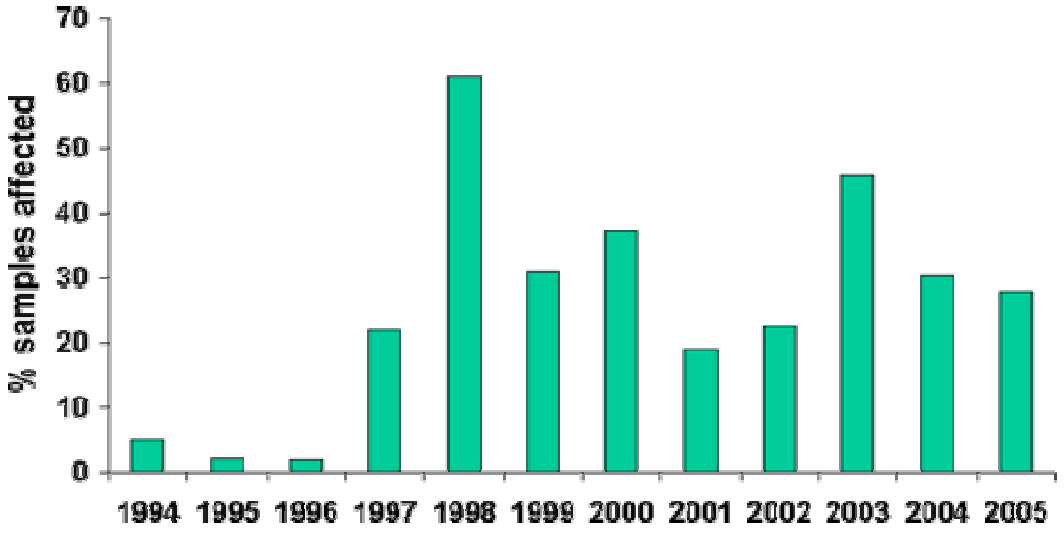
Fusarium: a complex problem

- Reduction of yield (10% to 50%)
- Qualitative damage: baking quality
- Germination problems after sowing
- Crown- and foot rot of young plantlets
- A problem from the field: it is a phytopathogenic fungus

Fusarium: a complex problem

- Problem is increasing throughout Europe

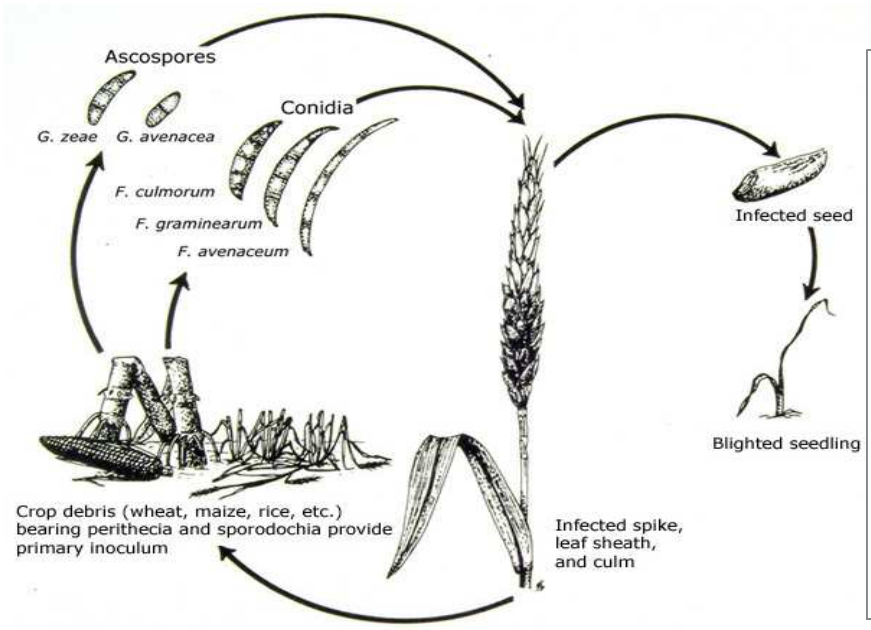


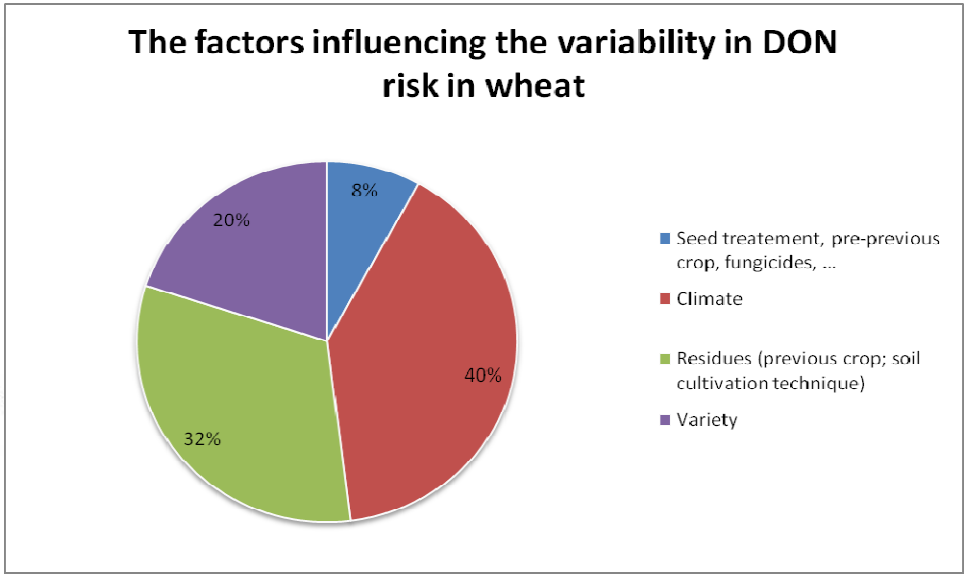
Fusarium: a complex problem

- European legislation on maximum levels of several mycotoxins (Nr. 1126/2007)

'2.4 Deoxynivalenol (17)		ppb
2.4.1	Unprocessed cereals (18) (19) other than durum wheat, oats and maize	1 250
2.4.2	Unprocessed durum wheat and oats (18) (19)	1 750
2.4.3	Unprocessed maize (18), with the exception of unprocessed maize intended to be processed by wet milling (*)	1 750 (20)
2.4.4	Cereals intended for direct human consumption, cereal flour, bran and germ as end product marketed for direct human consumption, with the exception of foodstuffs listed in 2.4.7, 2.4.8 and 2.4.9	750
2.4.5	Pasta (dry) (22)	750
2.4.6	Bread (including small bakery wares), pastries, biscuits, cereal snacks and breakfast cereals	500
2.4.7	Processed cereal-based foods and baby foods for infants and young children (3) (7)	200
2.4.8	Milling fractions of maize with particle size > 500 micron falling within CN code 1103 13 or 1103 20 40 and other maize milling products with particle size > 500 micron not used for direct human consumption falling within CN code 1904 10 10	750 (20)
2.4.9	Milling fractions of maize with particle size ≤ 500 micron falling within CN code 1102 20 and other maize milling products with particle size ≤ 500 micron not used for direct human consumption falling within CN code 1904 10 10	1250

Fusarium: a complex problem





Fusarium: a complex problem

- *Fusarium* is not one pathogen but a species complex
- 16 species cause identical symptoms
- *Fg, Fc, Fp, Mn, Fa* are important in Europe
- Population is dynamic with sometimes new species popping-up: e.g. *F. langsethiae*

Fusarium: a complex problem

- *Fusarium* produces mycotoxins which are toxic for humans and animals
- *Fusarium* has a diversified portfolio of mycotoxins depending on the species
- Within one species, several chemotypes
- These toxins are very rigid: heatstable, most are water extractable

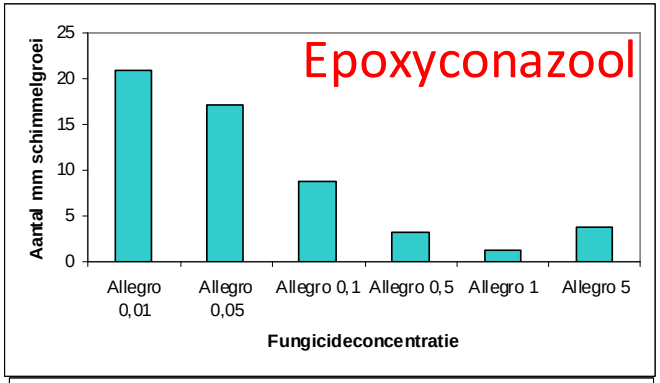
Fusarium: a complex problem

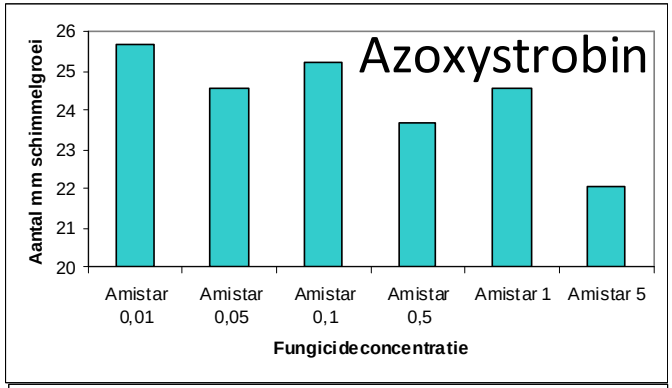
F. graminearum	**deoxynivalenol (DON, vomitoxine)** **zearalenone** **fusarin C** **nivalenol**
F. moniliforme	**fumonisine B1, B2 en B3** **fusarin C** **moniliformine**
F. poae	**T-2** **15-deacetylneosolanil**
F. culmorum	**culmorine** **moniliformine** **zearalenone** **deoxynivalenol (DON, vomitoxine)** **furasin C** **nivalenol**
F. avenaceum	**zearaleone, nivalenol, deoxynivalenol,**

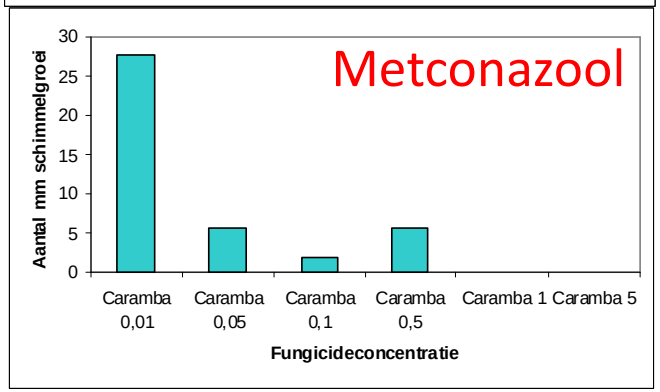
Fusarium: a complex problem

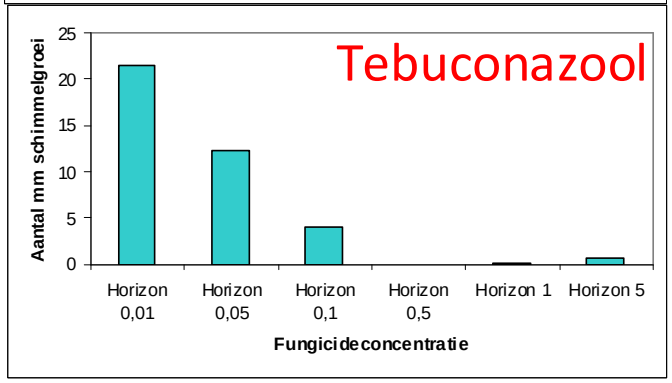
- No direct control of *Fusarium*
- Not all species are susceptible to all fungicides: differential response depending on species
- The time frame of good control is short: during anthesis

Fusarium: a complex problem

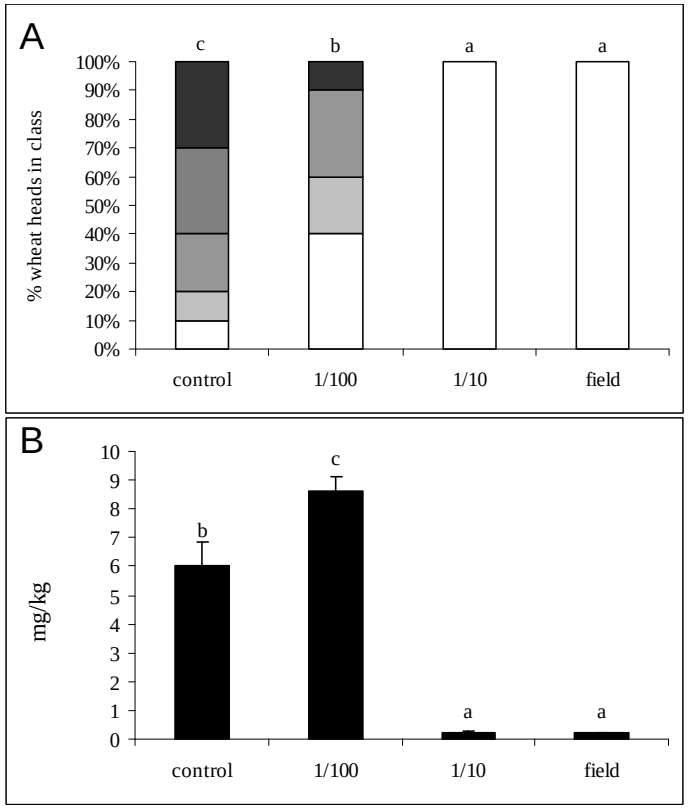








Fusarium: a complex problem

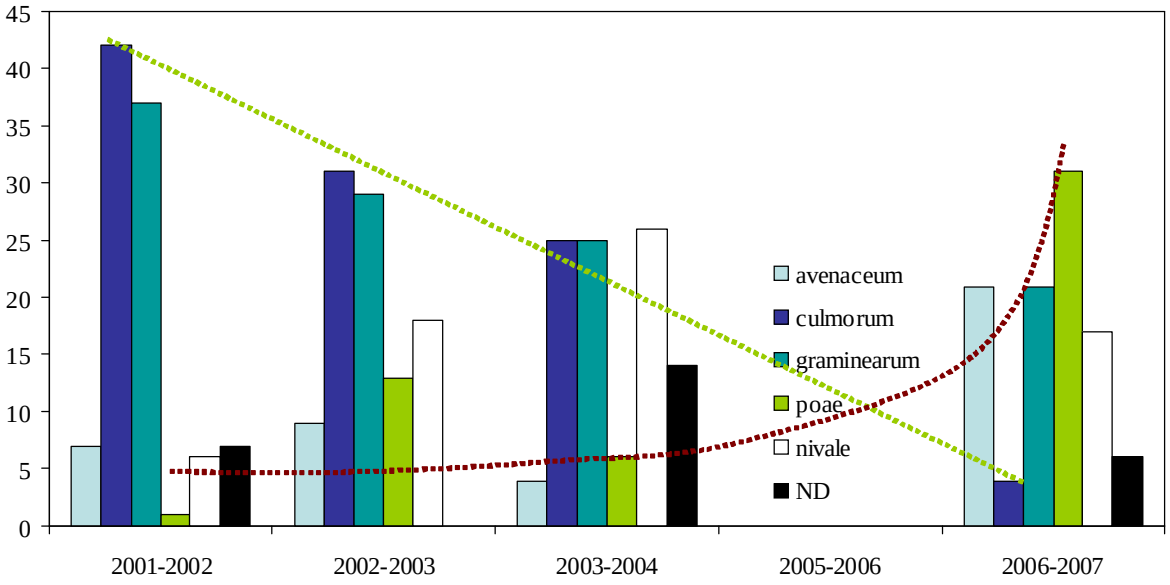


Fungicide treatments
not always optimal

Audenaert *et al.*, 2010 BMC Microbiology

Evolution *Fusarium* population and DON in Flanders (2002-2009)

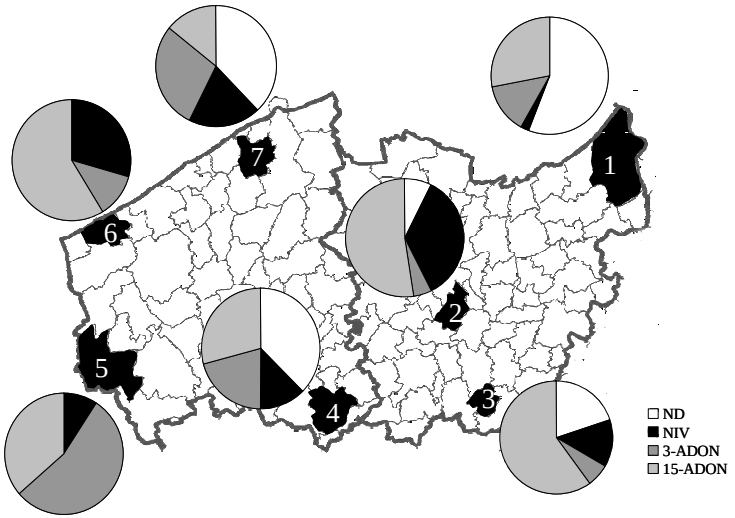
- Dynamics on the species level



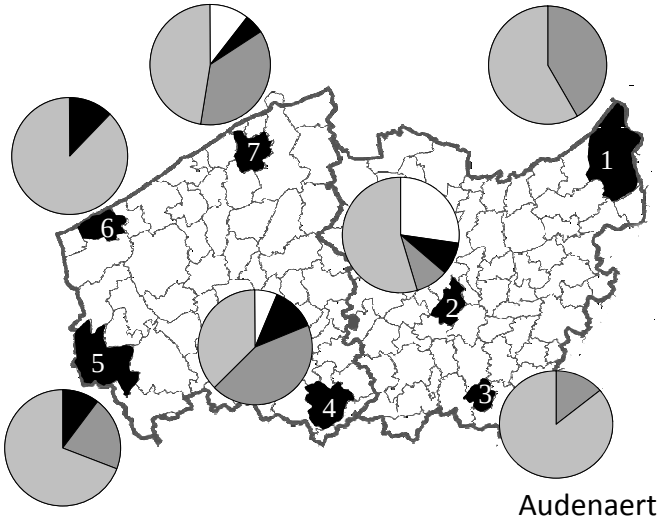
Audenaert et al, 2009
European Journal
of Plant Pathology (125): 445-458

Evolution *Fusarium* population and DON in Flanders (2002-2009)

- Dynamics on the chemotype level



2007



2008

Audenaert et al, 2009
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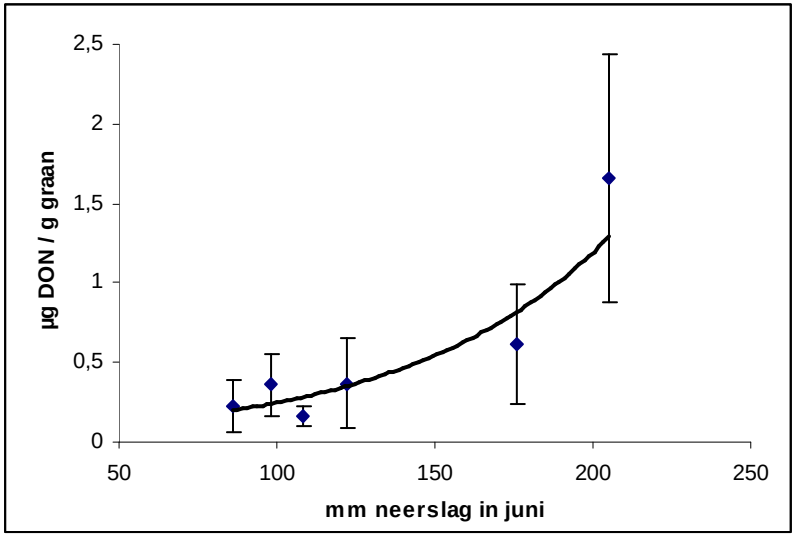
Evolution *Fusarium* population and DON in Flanders (2002-2009)

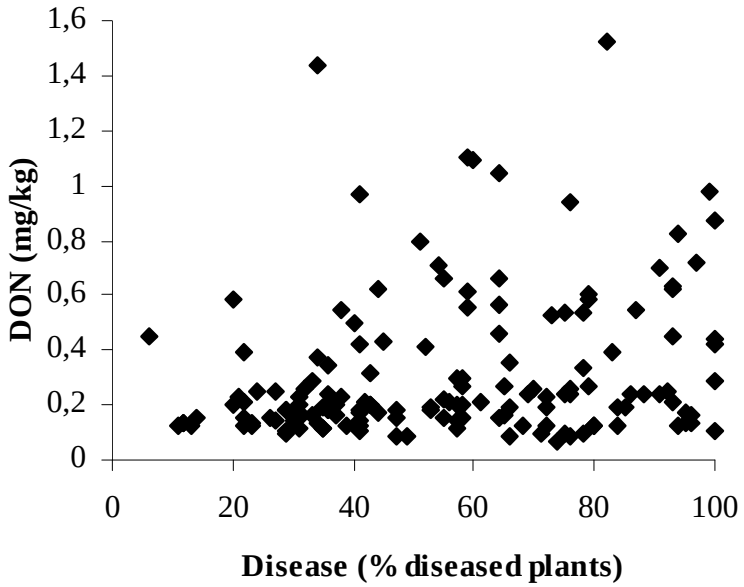
- Dynamics on the DON level

2007							
DON (mg/kg)	Lierde	Zuienkerke	Koksijde	Zwevegem	Verrebroek	Poperinge	Bottelare
Kaspart	**1.273** [b]	0.533 [ab]	0.596 [a]	0.183 [a]	0.213 [a]	1.215 [ab]	0.120 [a]
Lexus*	0.795 [a]	0.188 [a]	0.379 [a]	0.115 [a]	0.468 [ab]	**2.325** [bc]	0.289 [b]
Limes*	0.789 [a]	0.184 [a]	0.547 [a]	0.127 [a]	0.284 [a]	**1.540** [abc]	0.142 [a]
Patrel*	0.736 [a]	0.180 [a]	0.618 [a]	0.142 [a]	0.266 [a]	0.980 [a]	0.127 [a]
Robigus*	0.508 [a]	0.310 [a]	0.373 [a]	0.271 [a]	0.319 [a]	**1.678** [b]	0.182 [ab]
Rosario	0.616 [a]	0.637 [ab]	1.110 [a]	0.432 [ab]	0.611 [b]	**3.685** [c]	0.172 [ab]
Toisondor*	0.542 [a]	0.166 [a]	0.466 [a]	0.106 [a]	0.410 [ab]	**1.523** [b]	0.110 [a]
Tulsa	**1.701** [b]	0.177 [a]	0.438 [a]	0.118 [a]	0.423 [ab]	**2.406** [bc]	0.141 [ab]
Tuscan	1.108 [a]	0.707 [b]	0.848 [a]	0.570 [b]	ND	0.781 [a]	ND



Evolution *Fusarium* population and DON in Flanders (2002-2009)

- Relation between symptoms and DON



Audenaert et al, 2009
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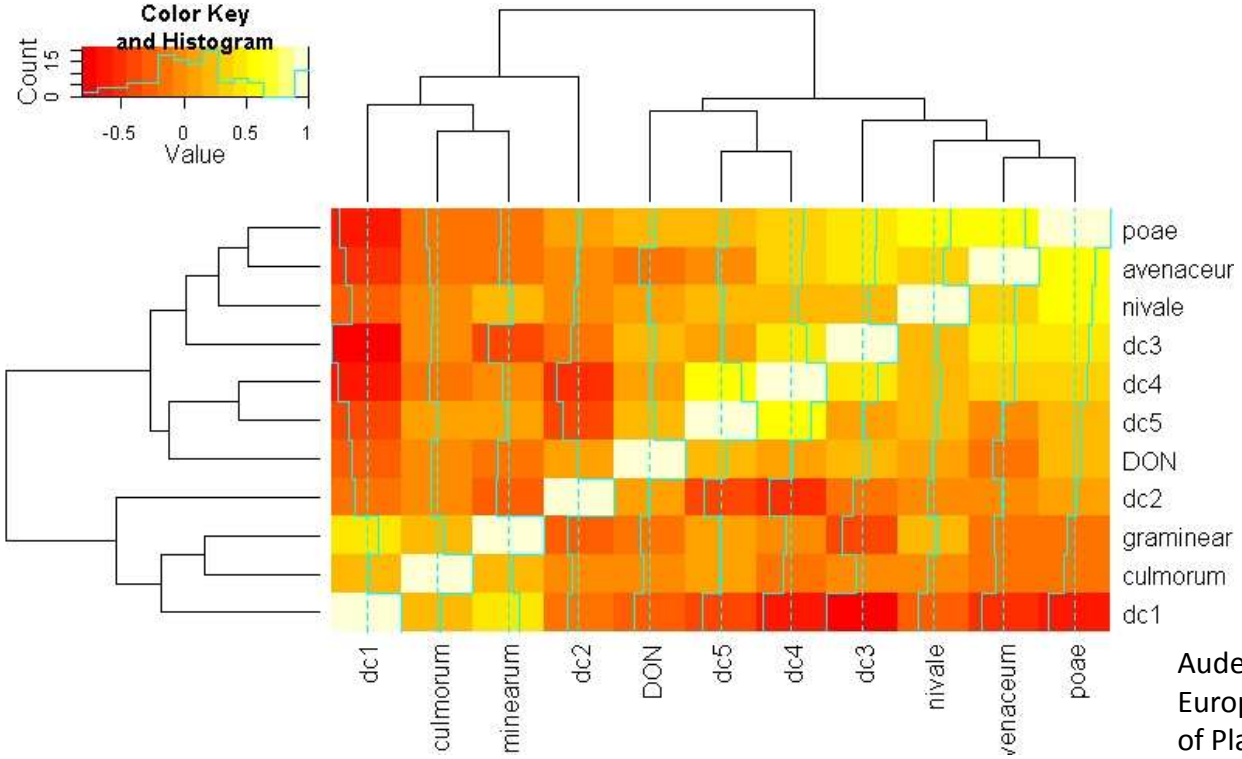
Associations within the population (2002-2009)



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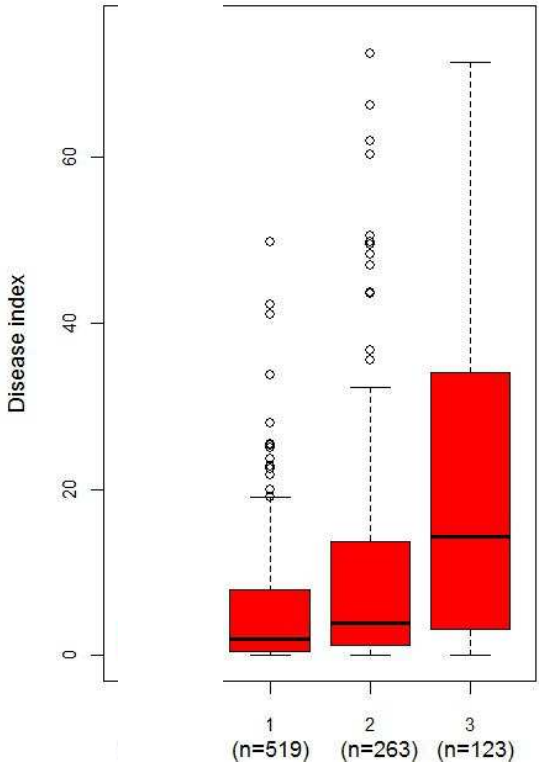
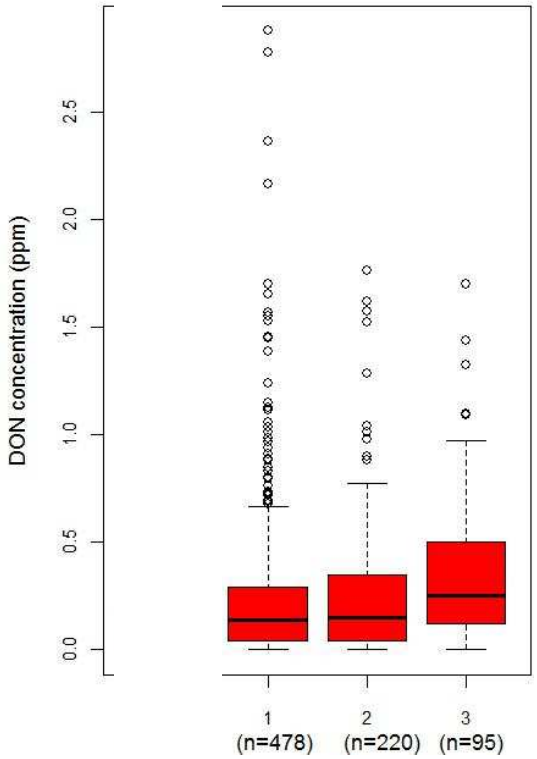
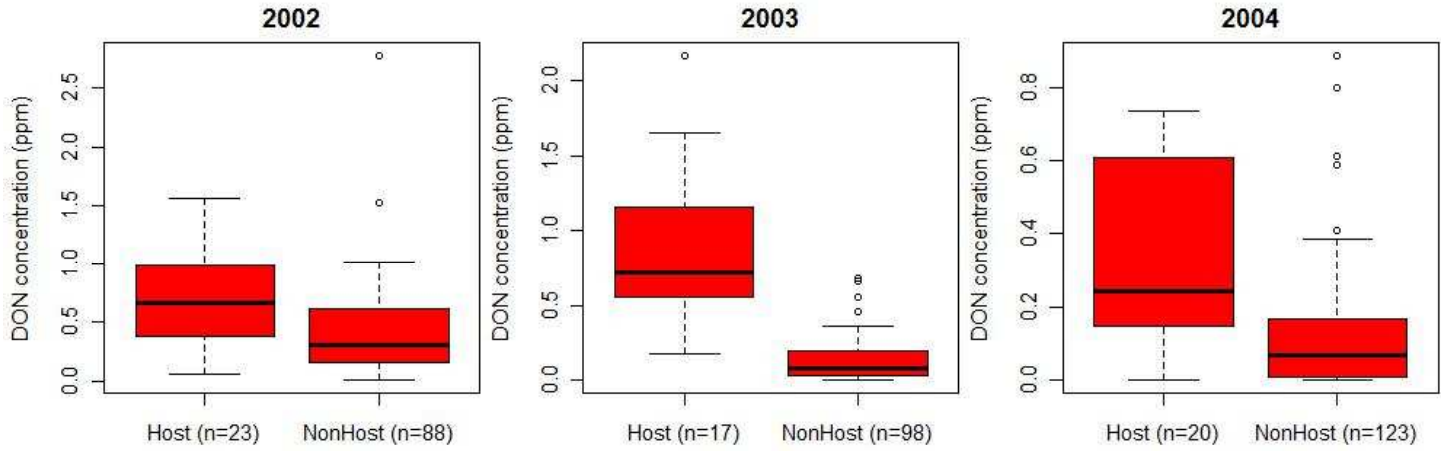
Empirical analysis of variables affecting *Fusarium* and DON





Landschoot et al, 2010
Submitted plant pathology

Empirical analysis of variables affecting *Fusarium* and DON



Landschoot et al, 2010
Plant Pathology, submitted

Empirical analysis of variables affecting *Fusarium* and DON

Weather and DON

Month	variable	negative	variable	positive
November	25%PRH	-0.25	AverageTemperature	0.29
December	25%PRH	-0.20	MedianPressure	0.40
January	Days Frost	-0.35	AverageTemperature	0.39
February	RH>80%	-0.33	AverageTemperature	0.46
March	Average RH	-0.17	AverageTemperature	0.41
April	Rainfall	-0.29	90%PTemperature	0.16
May	MedianPressure	-0.33	25%PTemperature	0.29
June	AveragePressure	-0.43	75%PRH	0.36
July	MedianTemperature	-0.38	10%PRH	0.32

INFECTION

Empirical analysis of variables affecting *Fusarium* and DON

Weather and symptoms

Month	variable	negative	variable	positive
November	25%PPressure	-0.38	10%PTemperature	0.64
December	Days Frost	-0.49	10%PTemperature	0.63
January	Days Frost	-0.51	75%PTemperature	0.68
February	MedianPressure	-0.67	75%PTemperature	0.70
March	Days Rain	-0.28	AverageDewpoint	0.60
April	Days Rain	-0.72	AveragePressure	0.66
May	25%PPressure	-0.62	MedianRH	0.27
June	MedianPressure	-0.68	RH>80%	0.67
July	75%PTemperature	-0.54	Rainfall	0.62

INFECTION

Empirical analysis of variables affecting *Fusarium* and DON

- Conclusion: *Fusarium* is a complex problem due to
  - » Multiple species
  - » Multiple toxins
  - » No good chemical control
  - » Many input variables affecting the problem
  - » …
- What can we do about it:

Prediction and advice for *Fusarium* and DON

- No use to come up with classical statistical models
  - Too many variables
  - To many types of variables (ordinal, nominal, longitundinal…)
  - None of the varibales is independent
- Therefore use regression based learning algoritms
- Use of support vectoring and machine learning techniques

An ambitious prediction of DON and Fusarium

Input variables:

- Year (ordinal)
- Location (8 bin)
- Wheat types (12 bin)
- Parallel (3 ordinal)
- Sowing and harvest date (continuous)
- Sowing density (continuous)
- Moisture type (5 bin)
- Preceding crop (2 bin)
- Average temperature (TS)
- Maximum temperature (TS)
- Minimum temperature (TS)
- Relative humidity (TS)
- Rainfall (TS)
- Leaf wetness (TS)
- Missing values: data inputation
- # of variables : 591

Output variables:

- DON levels (continuous)
- Disease classes (5 class mixed ordinal)
- Types of Fusarium (5 class multi-label)
- Missing values: data omission
- # of variables : 11

Fusarium research in UGent and Hogent

- Post-doc OF mandaat Hogent (2007-2012): Importance of Don in stress response of *Fusarium*
  - Dr. ir. K. Audenaert, Prof. dr. ir. M. Höfte, Prof. dr. ir. G. Haesaert
- Prediction of deoxynivalenol and Fusarium spp. via regression-based learning algoritms (IWT Landbouw project) (2008-2012)
  - Prof. B. De Baets, Dr. Ir. W. Waegeman, dr.ir. K. Audenaert, ir. Daniël Wittouck, ir. Lies Martens, Prof. dr. Ir. G. Haesaert
- Masked mycotoxins in food and feed (2010-2012) (FOD project)
  - Prof. dr. Apr. C. Van peteghem, Prof. dr. Apr. S. De Saeger,dr. Ir. K. Audenaert, Prof. Dr. Ir. M. Eeckhout, Prof.dr.ir. G. Haesaert
- tritrophic interaction ofaphids and Fusarium spp. on winter wheat (2010-2014) (AOG Project)
  - Prof.dr.ir. G. Smagghe, dr. ir. K. Audenaert, Prof. dr. ir. G. Haesaert
- Fusarium poae: mycotoxin pattern, chemotypes and oxidative stress (2010-2014) (OF project)
  - Dr.ir. K. Audenaert, Prof.dr.ir. M. Höfte, Prof. dr. Apr. S. De Saeger, Prof. Dr. Ir. G. Haesaert
- European project: Mycohunt: develop biosensors for mycotoxin detection
  - Dr.ir. K. Audenaert, Prof. dr. Apr. S. De Saeger, Prof. Dr. Ir. G. Haesaert, Prof. Dr. Ir. Mia Eeckhout

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Femke Vekeman
Ellen Vandeputte
Prof. Sarah de Saeger
Peter Maene
Ellen Vandeputte
Annelies Deschynckel
Prof. Monica Höfte
Prof. Bernard De Baets
Daniël Wittouck
Lies Martens
Prof. Guy Smagghe
Prof. Geert Haesaert

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