SEEDS OF ANIMAL NUTRITION SYMPOSIUM

Agronomic factors related to mycotoxin contamination of corn

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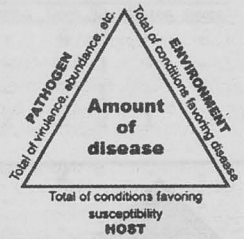
Ear rots and mycotoxins

- Pathogens & their mycotoxins
- Where they occur
- Infection processes
- Environmental influences
- Management influences

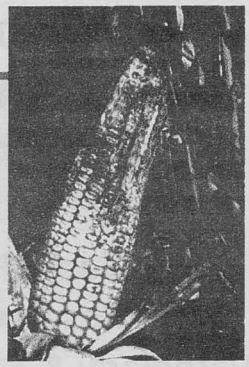


Fusarium ear rot

- *Fusarium verticillioides*
  - *F. proliferatum, F. subglutinans*
  - 8 other species (Bottalico, 1998)
- Sexual stage uncommon, heterothallic
- Fumonisins, moniliformin, fusaproliferin
- Lower latitudes

Gibberella ear rot

- *Gibberella zeae* (*Fusarium graminearum*)
  - 10 other species (Bottalico, 1998)
- Sexual stage common, homothallic
- DON, other trichothecenes
- Zearalenone
- Higher latitudes

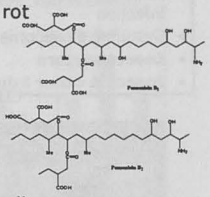


Aspergillus kernel rot

- *Aspergillus flavus, A. parasiticus*
- Sexual stage uncommon
- Aflatoxins, sterigmatocystin
- Lower latitudes, tropical & semi-tropical areas, high temperatures (competes well in drought)

Mycotoxins in corn

- Aflatoxins – Aspergillus kernel rot
  - Potent liver toxin
  - immunosuppression
  - Carcinogenic, milk contamination
- Fumonisins - Fusarium ear rot
  - Fatal diseases in horses & pigs
  - Affects brain, heart, liver, lungs, kidneys
  - Carcinogenic; birth defects?
- Deoxynivalenol (DON) - Gibberella ear rot
  - Feed refusal, vomiting, poor weight gain in swine
- Zearalenone, Other *Fusarium* toxins



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Geographic variation

- Major mycotoxin varies by latitude
  - Aflatoxins⟶Fumonisins ⟶ DON ⟶ NIV
  - Adaptation of fungi to temperature
- N. American pattern mirrored in Europe, South America (latitude & altitude)

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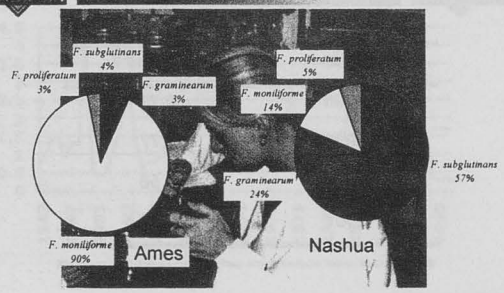
Fusarium species composition in corn kernels



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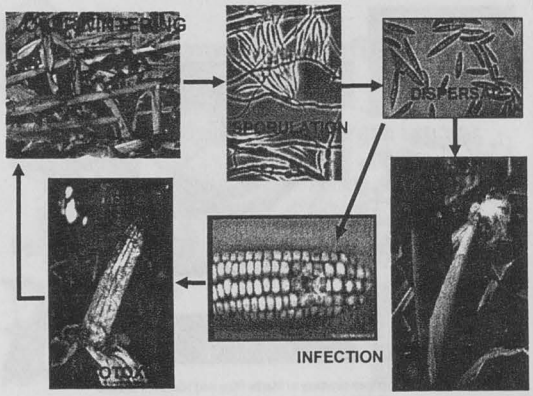
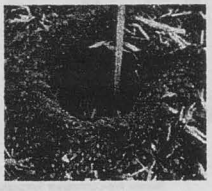
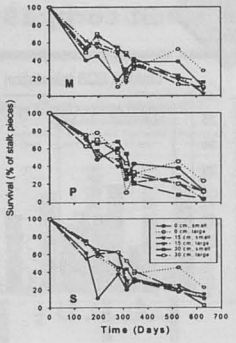


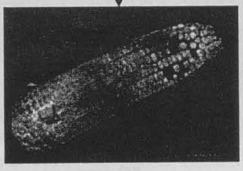
Survival of *Fusarium* spp. in stalk residue

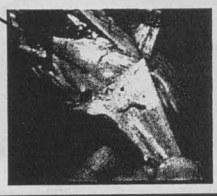




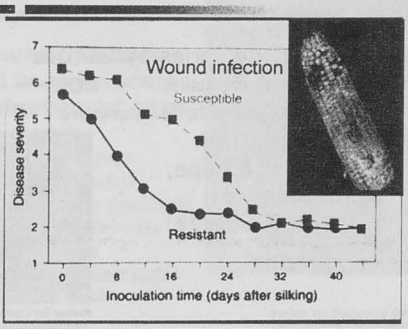
Dispersal/infection pathways, *F. graminearum*

- **Airborne spores – silk infection**
- Insect vectors
- Insect & other injuries



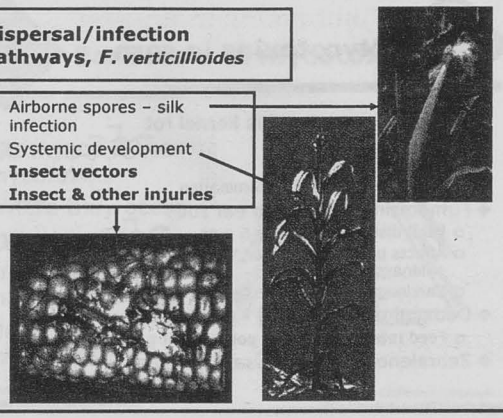


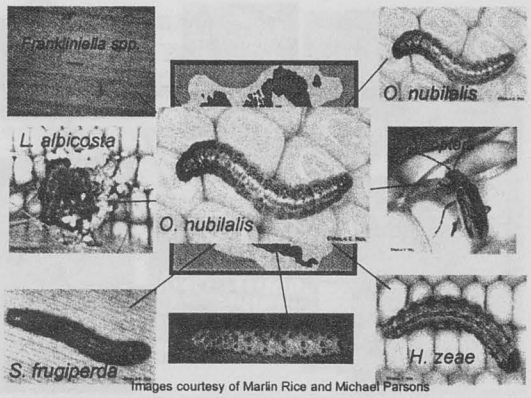
Susceptibility of ears to *F. graminearum*



Dispersal/infection pathways, *F. verticillioides*

- Airborne spores – silk infection
- Systemic development
- **Insect vectors**
- **Insect & other injuries**





Images courtesy of Marlin Rice and Michael Parsons

Correlation coefficients for insect injury and and fumonisins in Iowa, 1998-2001

Year	Coefficient
1998	0.77
1999	0.77
2000	0.58
2001	0.72

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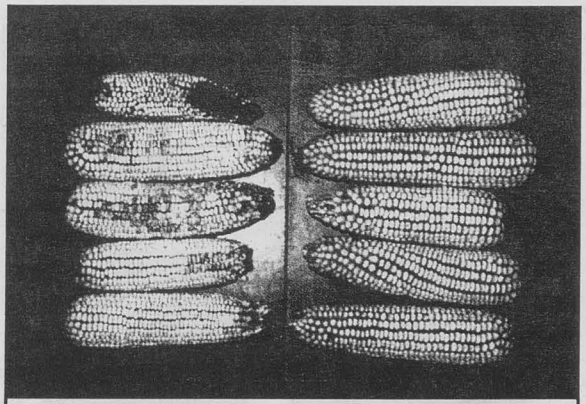

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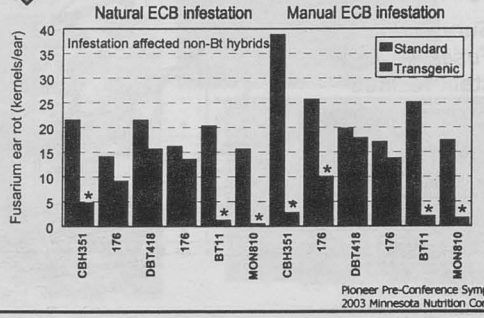
Fusarium ear rot in Bt/non-Bt corn, 1997



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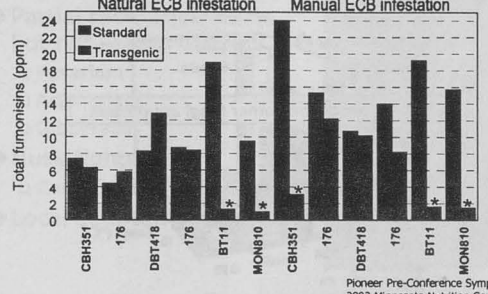
Fumonisins in Bt/non-Bt corn, 1997



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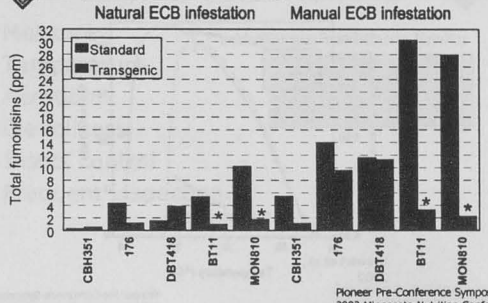

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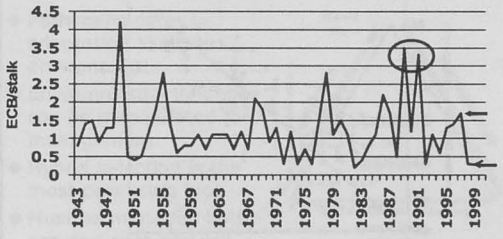
European corn borer densities: Illinois, 1943-2000



JE Carpenter, National Center for Food and Agriculture Policy, Washington, DC

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Environmental influences

- Fusarium ear rot
  - Drought conditions
  - Higher optimum temperature
  - Importance of kernel injury
- Gibberella ear rot
  - High rainfall during & after silking
  - Temperatures of 25 to 30 C
  - 14 hr wetness periods

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Environmental influences

Years, location, and method of determining ear-rot prevalence	Months for which rainfall was used in calculations	Correlation coefficients between rainfall in specified months and ear rot caused by — All causes	*Diplodia zeae*	*Fusarium moniliforme*	*Gibberella zeae*	*Nigrospora oryzae*
1934-1941, Urbana (Ear examinations[a])	June	− .204	.015	− .460	.171	.196
	July	− .499*	− .247	− .468*	− .002	− .213
	June and July	− .455	− .149	− .603**	.011	− .006
	Aug.	.329	.461	− .235	.464	.517*
	Sept.	.613**	.326	.401	.442	.484*
	Oct.	.198	.437	− .038	.067	− .275
	Aug. and Sept.	.709**	.539*	.208	.640**	.705**
	Aug., Sept., Oct.	.651**	.635**	.144	.533*	.418
1940-1951, Urbana (Kernel examinations[a])	Aug.	.320	.055	.643*	.250	.299
	Sept.	.651*	.702*	.467	− .183	.062
	Oct.	.470	.415	.639*	.227	− .034
	Aug. and Sept.	.635*	.549	.628*	.012	.222
	Aug., Sept., Oct.	.797**	.629*	.725**	.176	.105

Koehler, 1959

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Quantitative modeling of Fusarium & Gibberella ear rots

- Vigier et al., 1997
  - Multiple regression (R^2 = 0.70)
  - July rainfall, fungal incidence, mode of entry
- Stewart et al., 2002
  - Post-inoculation events
  - Differential equation (R^2 = 0.89)
  - $dG/dt = a_1 G T_f W_f$
  - Silk function to account for silk age

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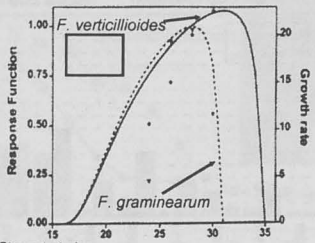
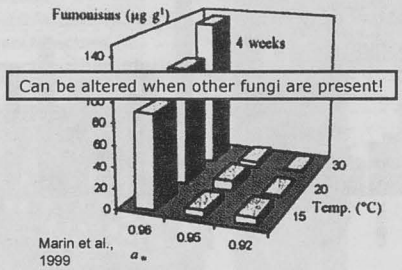
Temperature effects



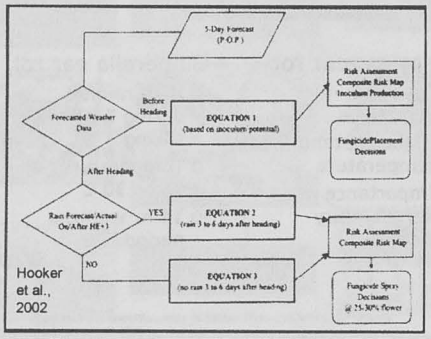
Stewart et al., 2002

Temperature effects on fumonisin production by *F. verticillioides*



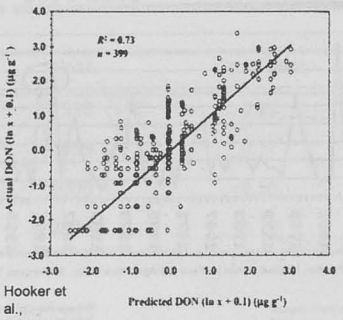
Marin et al., 1999

Quantitative modeling of DON concentrations in wheat



Hooker et al., 2002

Quantitative modeling of DON concentrations in wheat



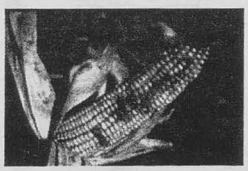
Hooker et al., 2002

Management influences

- Fusarium ear rot
  - Ubiquitous – tillage & crop rotation do not work
  - Insect control critical
  - Planting & harvest date
  - Genetic resistance
- Gibberella ear rot
  - Tillage & crop rotation may have some effect
  - Insect control may have some effect
  - Planting & harvest date
  - Genetic resistance

Management influences

- Aspergillus kernel rot
  - Avoid drought stress
    - Irrigation
    - Planting date, density
    - Deep tillage
    - Weed management
  - Insect control
  - Fertilization
  - Harvest date
  - Genetic resistance



Hybrid selection to avoid ear rots & mycotoxins

- Partial resistance exists, but not widely utilized
  - Fusarium
  - Aspergillus
  - Gibberella
- Husk tightness
  - Can work both ways
- Local adaptation of hybrids

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Grain management in storage is critical

- Moisture
- Temperature
- Aeration
- Cleanliness
- Insect control
- Frequent inspection

Grain moisture limits

A. flavus	~16%
F. verticillioides	~19%
G. zeae	~20%

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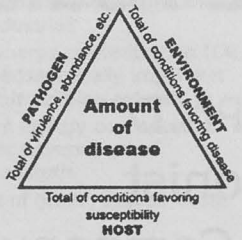
Summary

- Pathogens differ in adaptation to the environment
- Environmental influence can be manipulated for management
- Hybrid selection is the most promising tool
- Must be managed both pre-and post-harvest



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