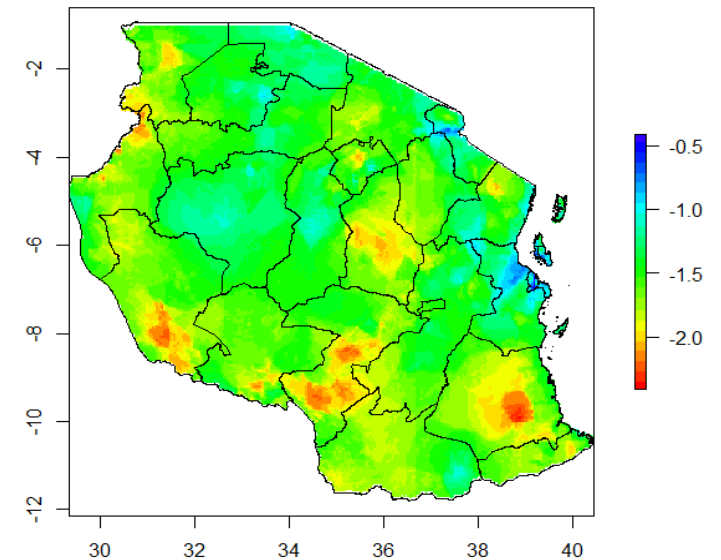


# Genetics of Resilience: Scales, Sacrifices and Strategies



Rebecca Nelson  
Cornell University  
**Genetic strategies and  
challenges to mitigate pest/  
pathogen infections**



R. Hijmans: stunting in Tz, 2010



**Northern Leaf Blight (NLB)**  
*Setosphaeria turcica*

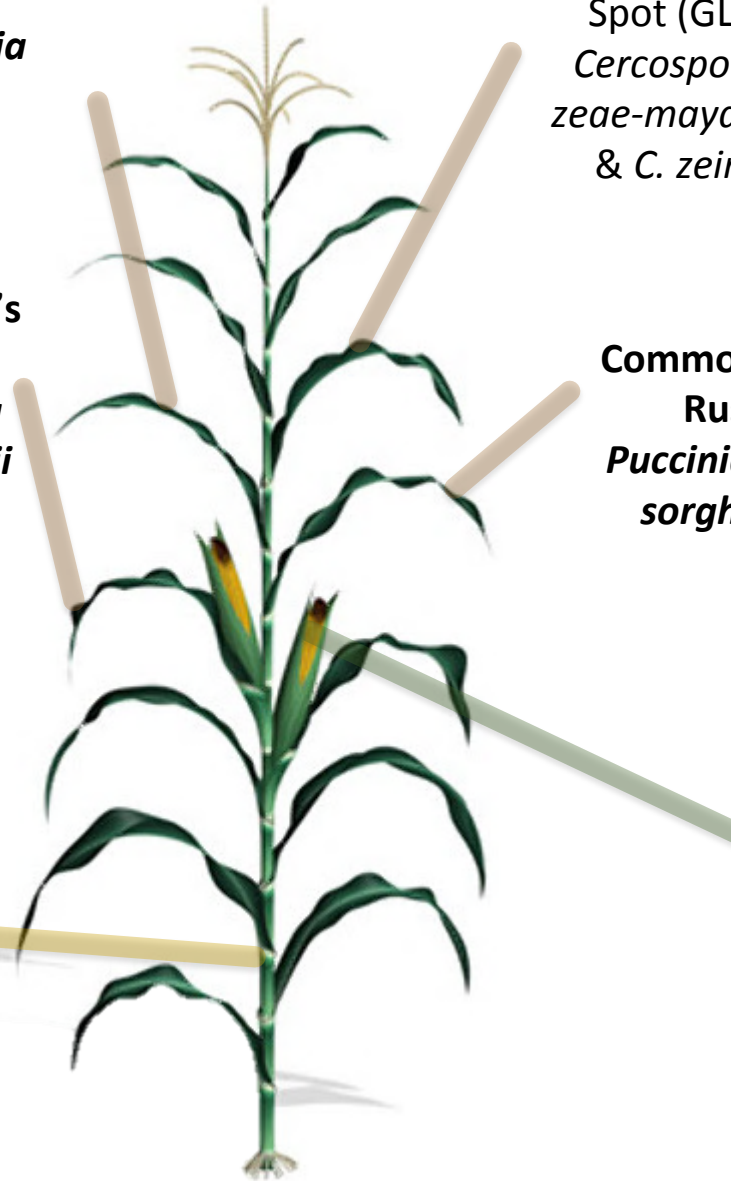


**Stewart's Wilt**  
*Pantoea stewartii*



C. Chung

**Anthracnose Stalk Rot**  
*Colletotrichum graminicola*



[http://biology.phillipmartin.info/biology\\_corn\\_plant.html](http://biology.phillipmartin.info/biology_corn_plant.html)

**Gray Leaf Spot (GLS)**  
*Cercospora zea-maydis* & *C. zeina*



J. Benson

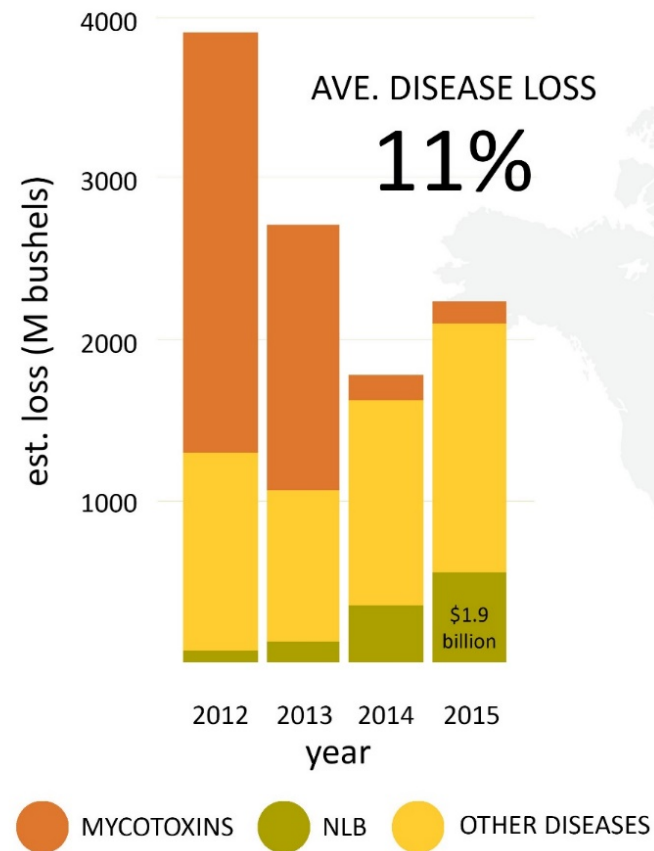
**Common Rust**  
*Puccinia sorghi*



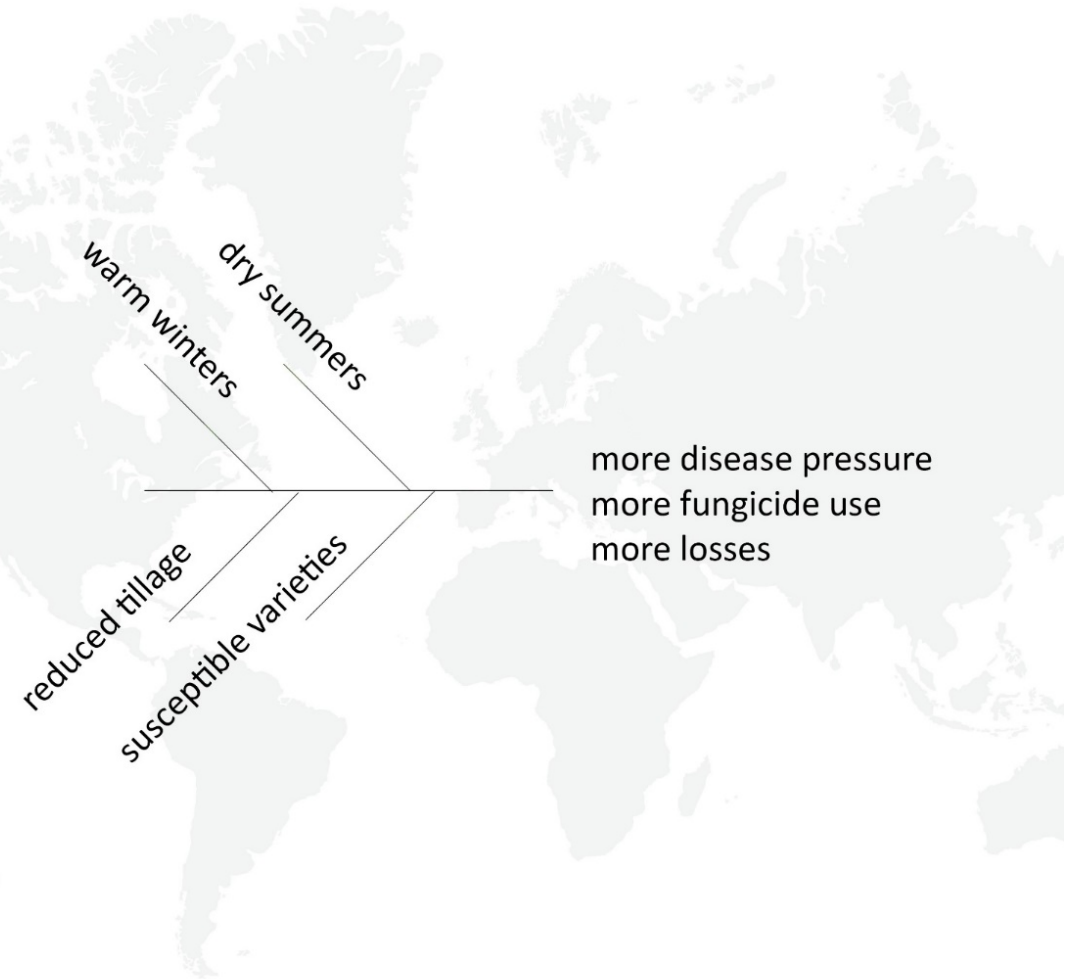
L. Morales

**Ear Rots**  
*Aspergillus flavus*  
*Fusarium verticillioides*

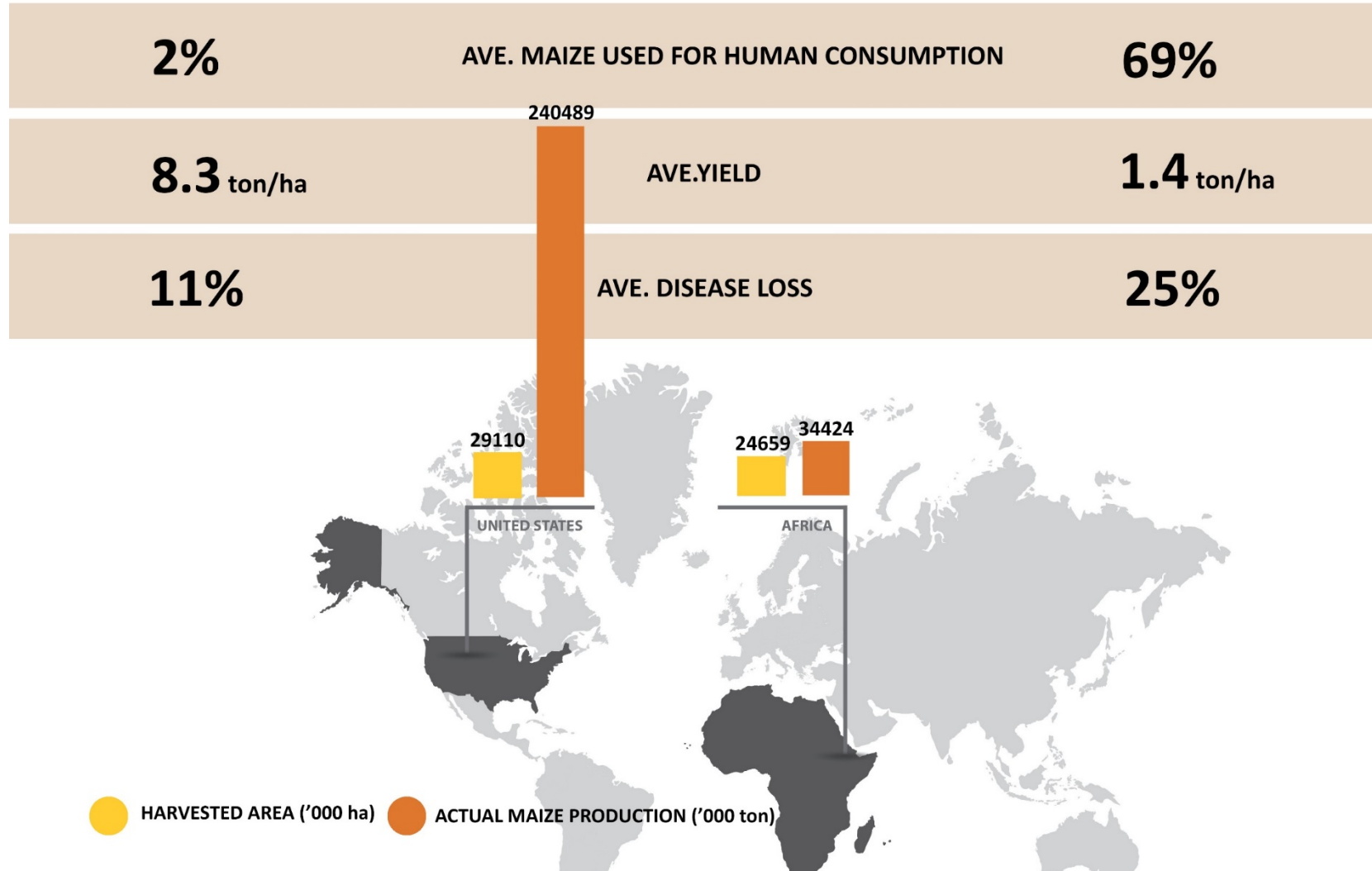
# Disease losses in maize in recent years, USA/Canada



Source: Mueller et al. 2016

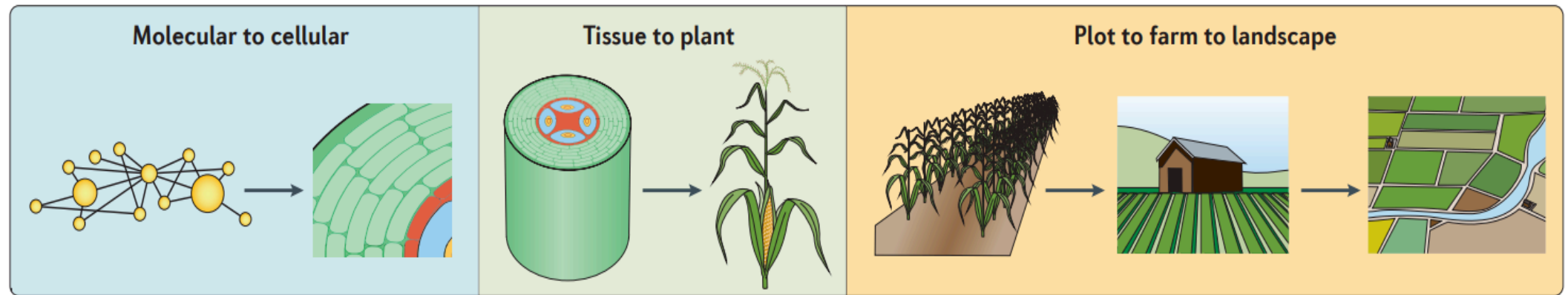
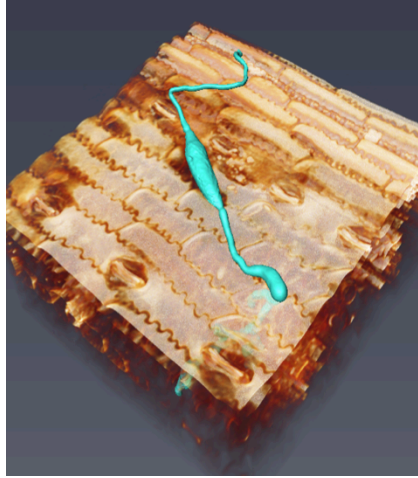
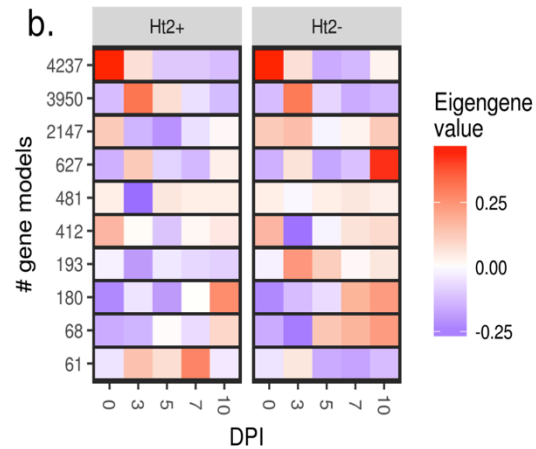


# It's much tougher for African farmers



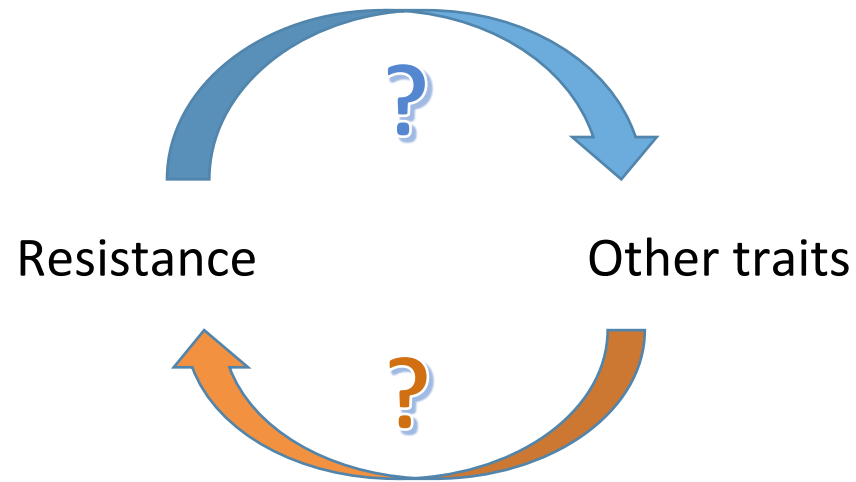


# Resistance at different scales



Nelson RJ, Wiesner-Hanks T, Wisser RJ, Balint-Kurti P (2018). Navigating complexity to breed disease-resistant crops. *Nature Reviews*

# Trade-offs?

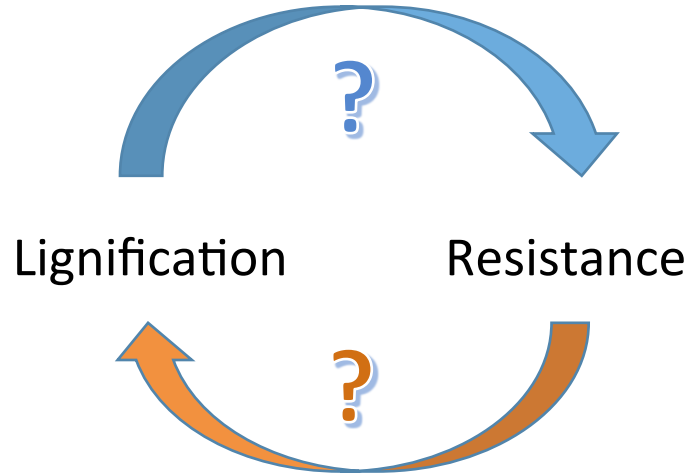


Ceballos et al. 1991: Recurrent selection for NLB, no big effect on yield or maturity

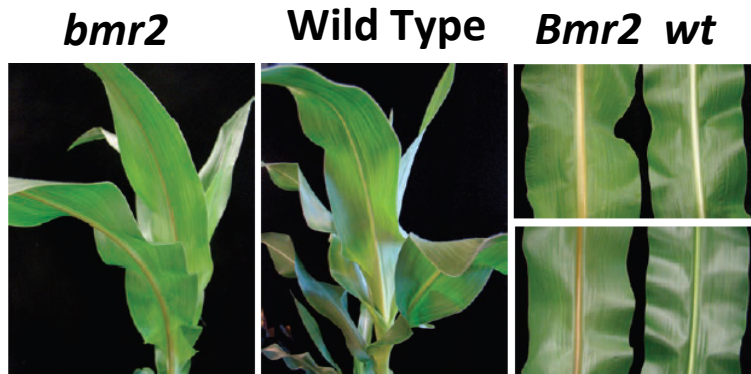
Two cases:

- Forage maize in upstate NY
- Mycotoxins in Africa

# Lower lignin --> more digestible maize for cows... and fungi?



Brown midrib silage corn  
Less lignin



# Brown midrib maize is susceptible to diseases



Northern Leaf Blight



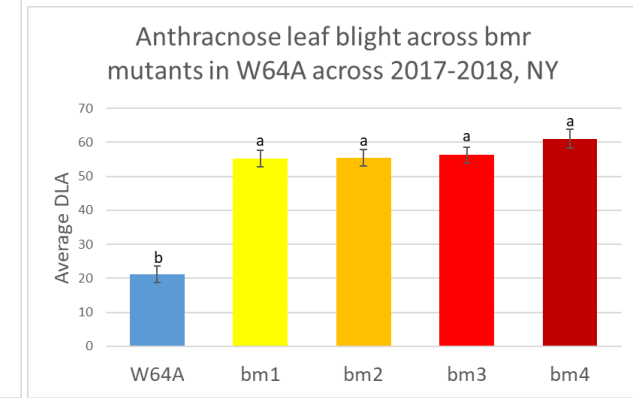
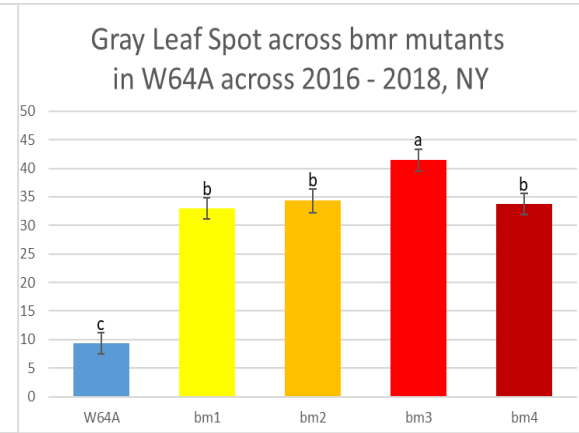
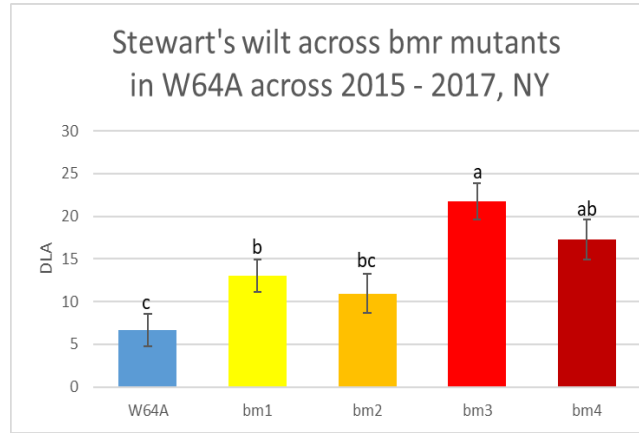
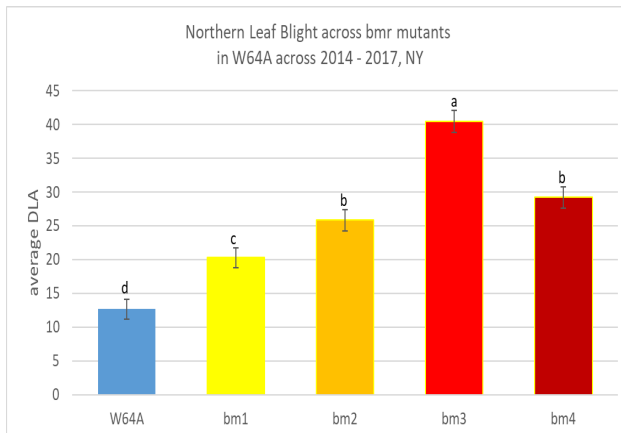
Stewart's Wilt



Gray Leaf Spot

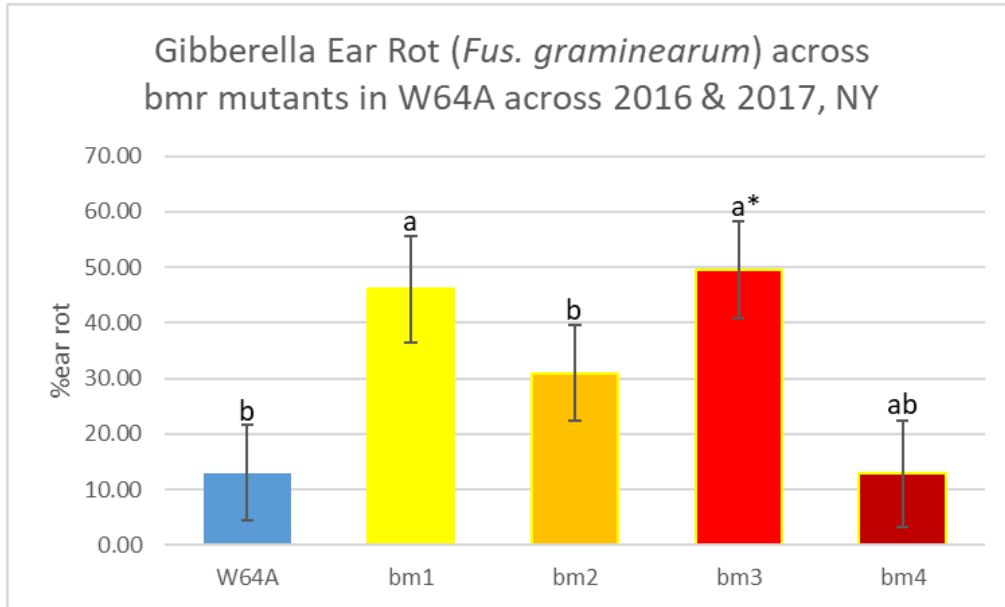


Anthracnose leaf blight

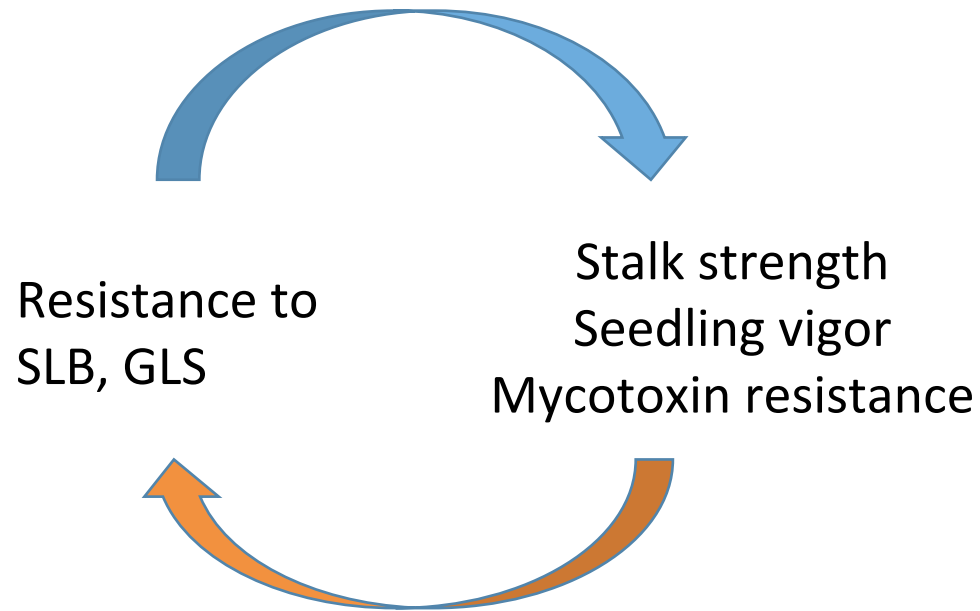




# More ear rot = ??? More mycotoxins ???



# Gene(s) in phenylpropanoid pathway have multiple roles



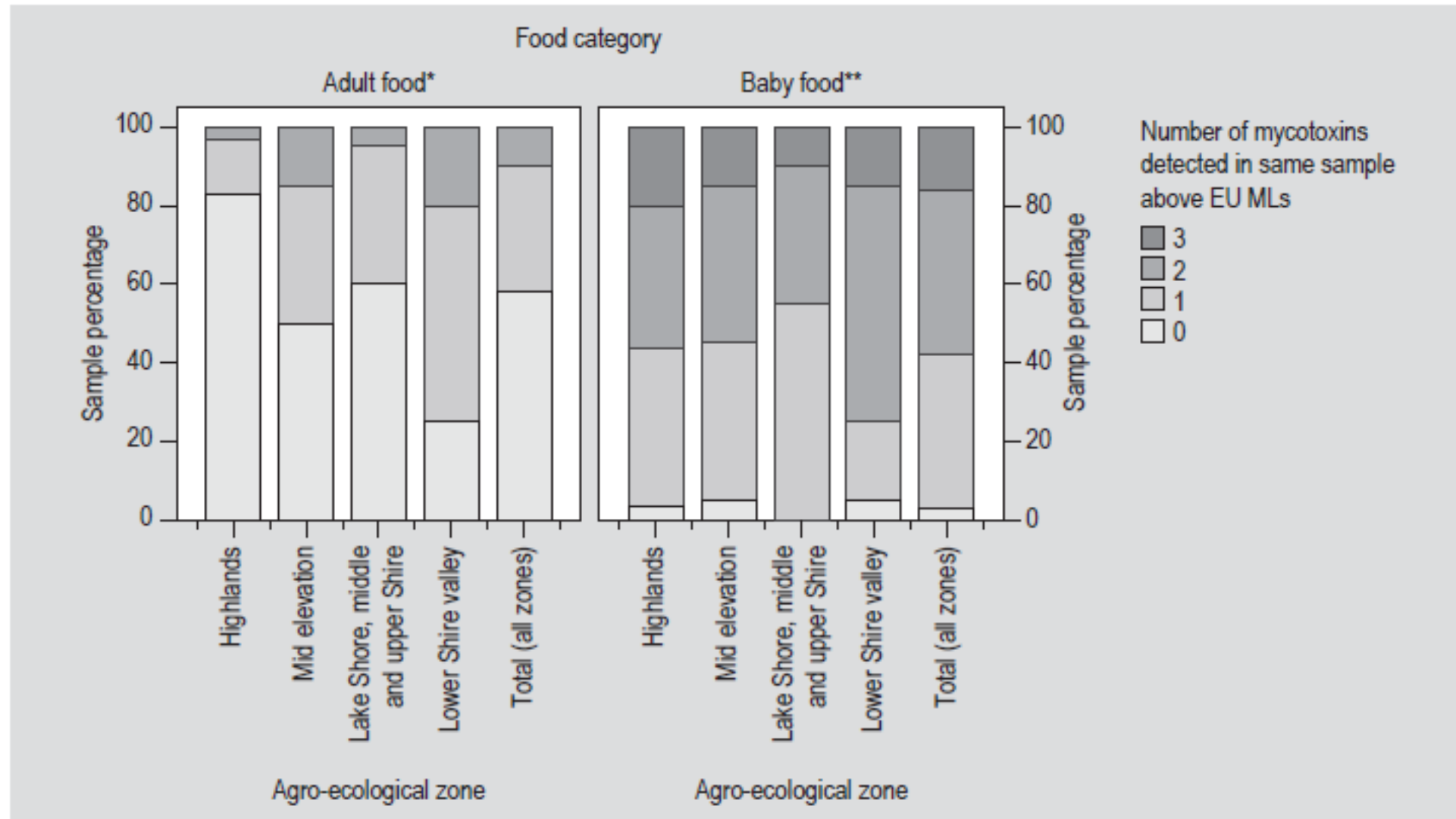
“Good alleles” for multiple disease resistance are also good alleles for other traits (e.g., stalk strength)

- Caffeoyl-CoA O-methyltransferase (CCOMT)
- Natural allelic differences associated with traits
- Resistance to two diseases
- NILs:
  - Rind penetrometer resistance
  - Fusarium ear rot (FUM)

# Lots of fungi on food, lots of toxic metabolites

Fungi	Mycotoxin	Food Commodities	Health Issues
<i>Aspergillus flavus</i>	Aflatoxins (AF)	Cereals (esp. maize), groundnuts, tree nuts, milk	Acute hepatitis and liver cancer; growth impairment; immunosuppression
<i>Fusarium verticillioides</i>	Fumonisin (FUM)	Maize, sorghum	Growth impairment; neural tube defects; esophageal cancer
<i>F. graminearum</i>	Deoxynivalenol (DON)	Cereals (esp. wheat and maize)	Toxicity; reduced feed intake and growth

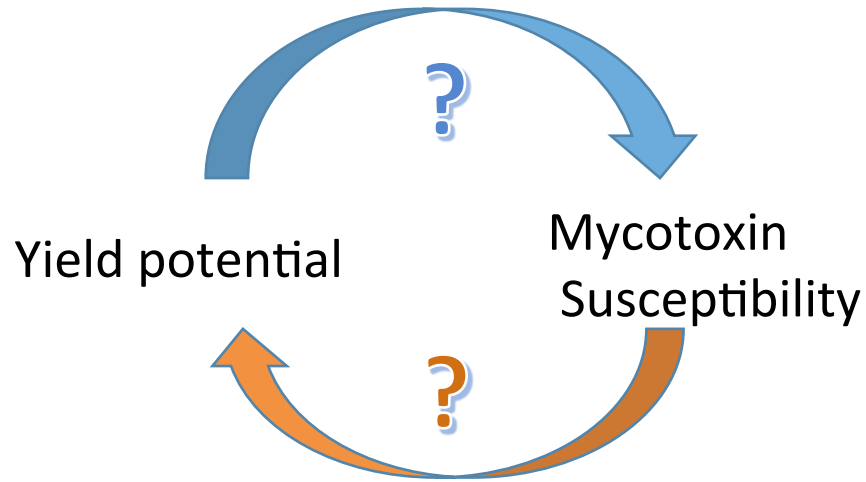
# Multiple toxins with babies hardest hit





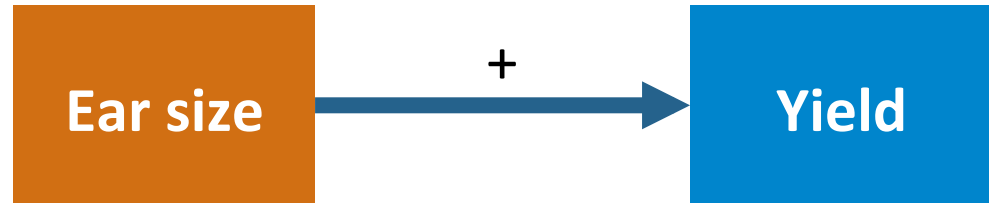
# Does breeding for high yield lead to toxin susceptibility?


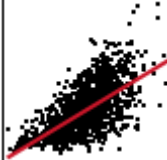
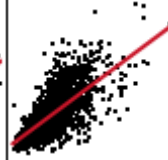
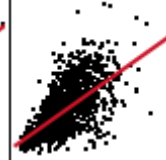
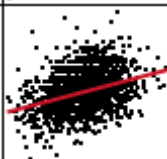
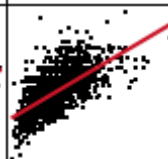
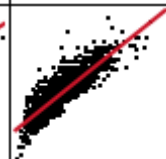
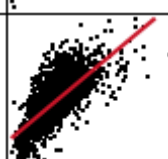
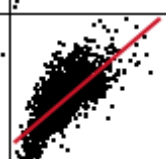
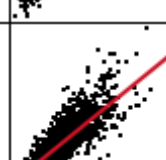
## Does breeding for toxin resistance lead to low yield?



Morales et al., 2018, 2019  
Mutiga et al., 2017

# We've been breeding for BIG



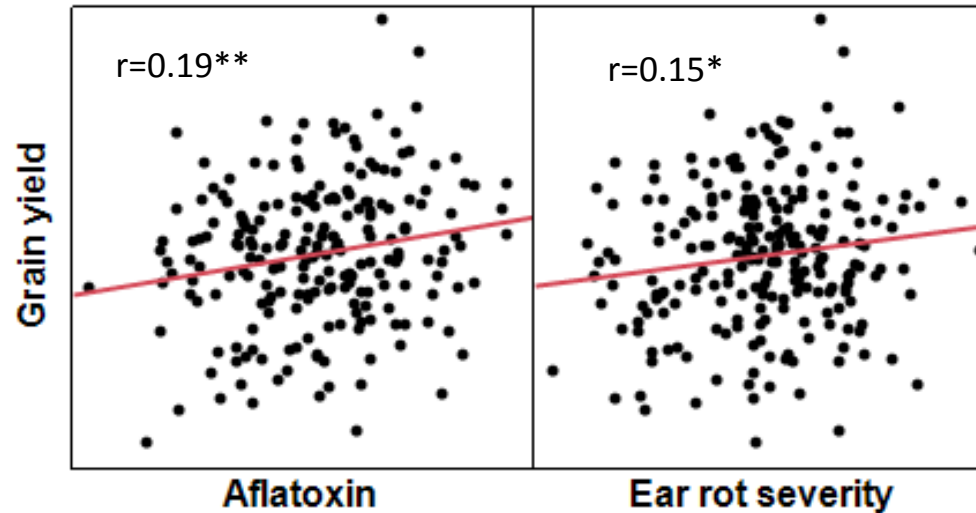
Grain yield				
$r=0.43$ ***	Cob diam.			
$r=0.64$ ***	$r=0.34$ ***	Cob length		
$r=0.66$ ***	$r=0.64$ ***	$r=0.71$ ***	Cob mass	
$r=0.62$ ***	$r=0.87$ ***	$r=0.72$ ***	$r=0.82$ ***	Cob vol.

Correlations among grain yield and cob phenotypes in the maize 282 diversity panel  
\*\*\*Pearson correlation ( $r$ )  $P < .0001$

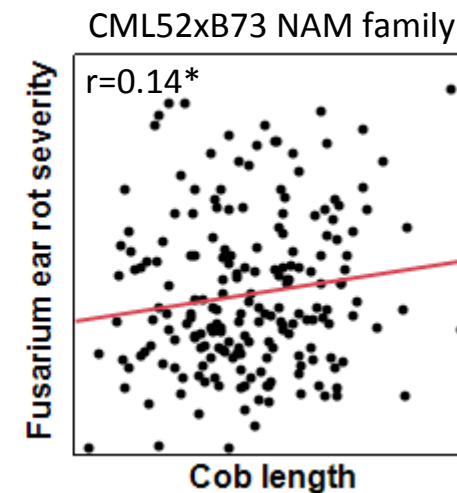
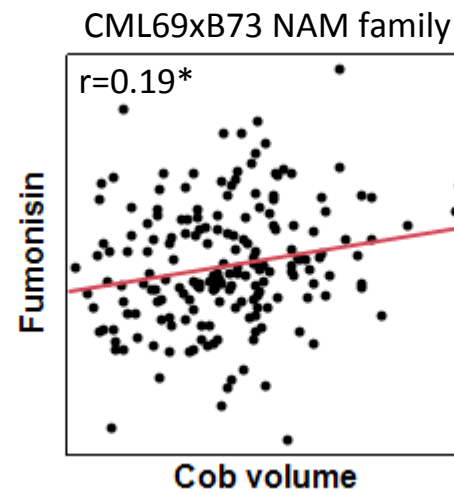
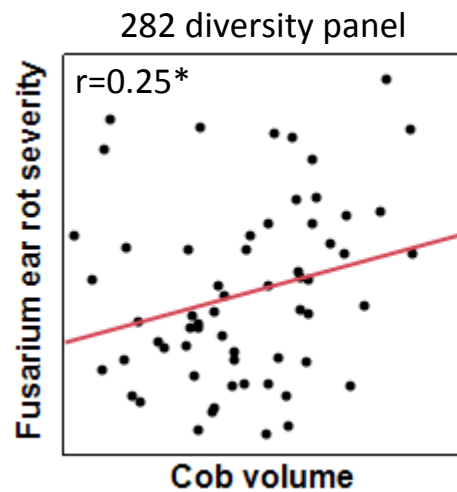
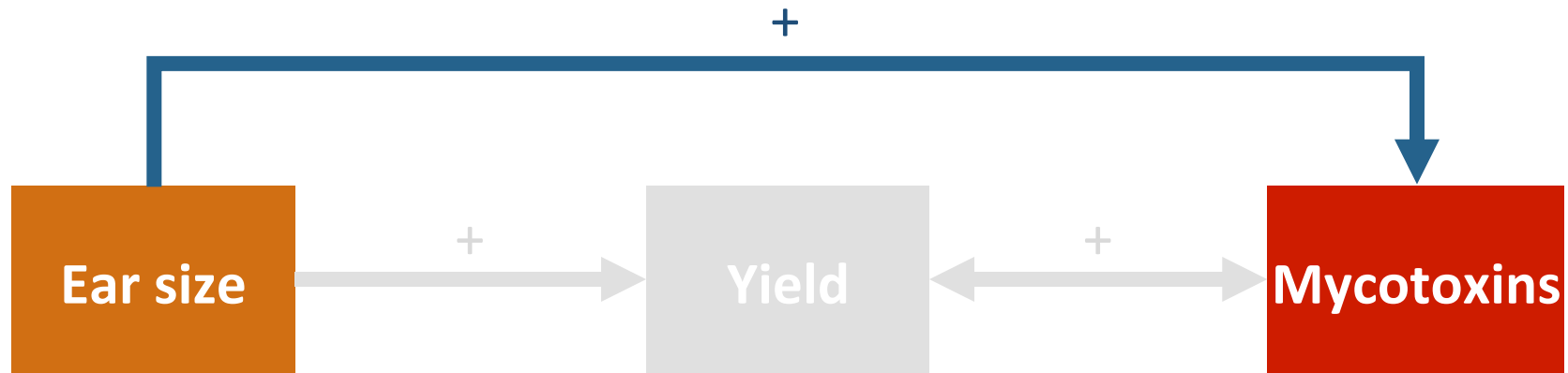
In tropical germplasm, grain yield is positively correlated with aflatoxin contamination and ear rot severity



Correlations ( $r$ ) between  
genotypic-means from CIMMYT  
IMAS population  
\* $P < 0.05$ ; \*\* $0.05 > P > 0.01$



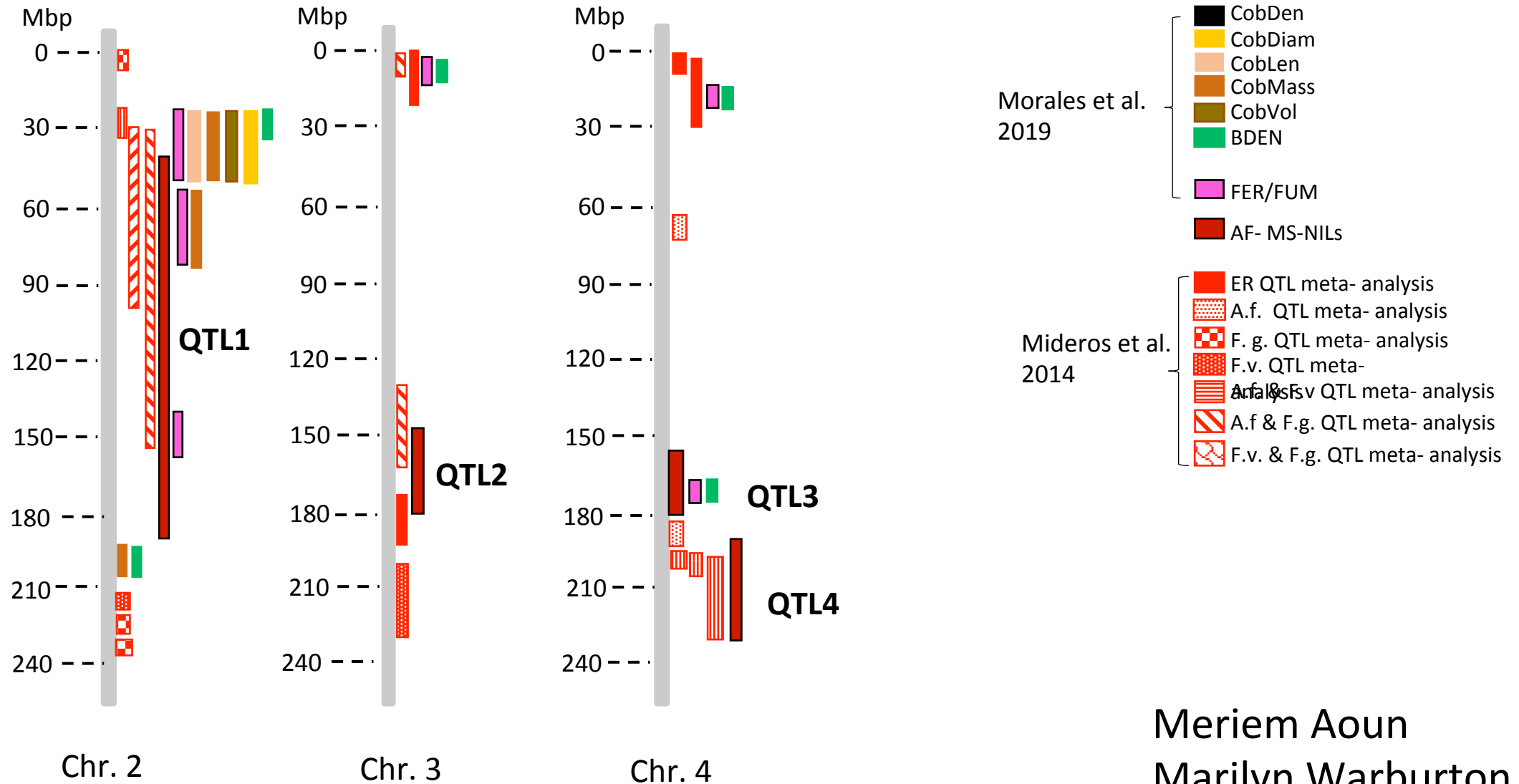
In genetic mapping populations, yield components are positively correlated with fumonisin contamination and ear rot



Correlations ( $r$ ) between genotypic-means  
\* $P<0.05$



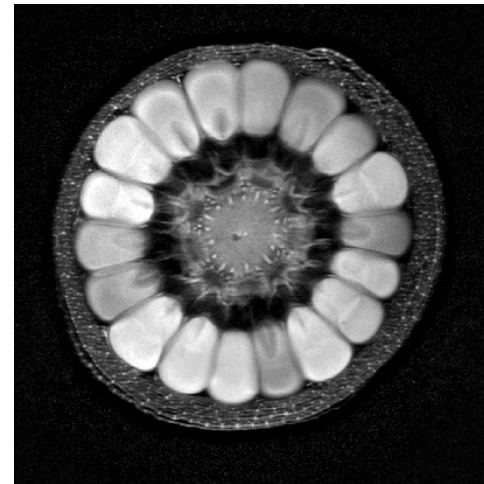
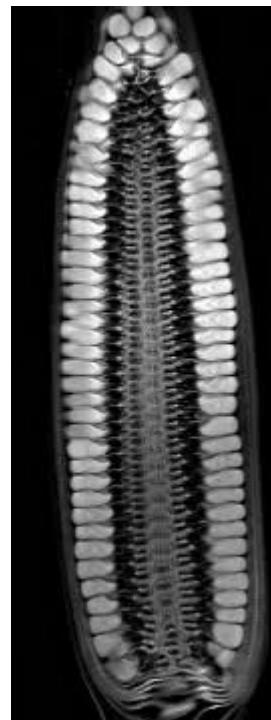
# Aflatoxin resistance QTL co-localize with QTL for ear traits and other ear rots



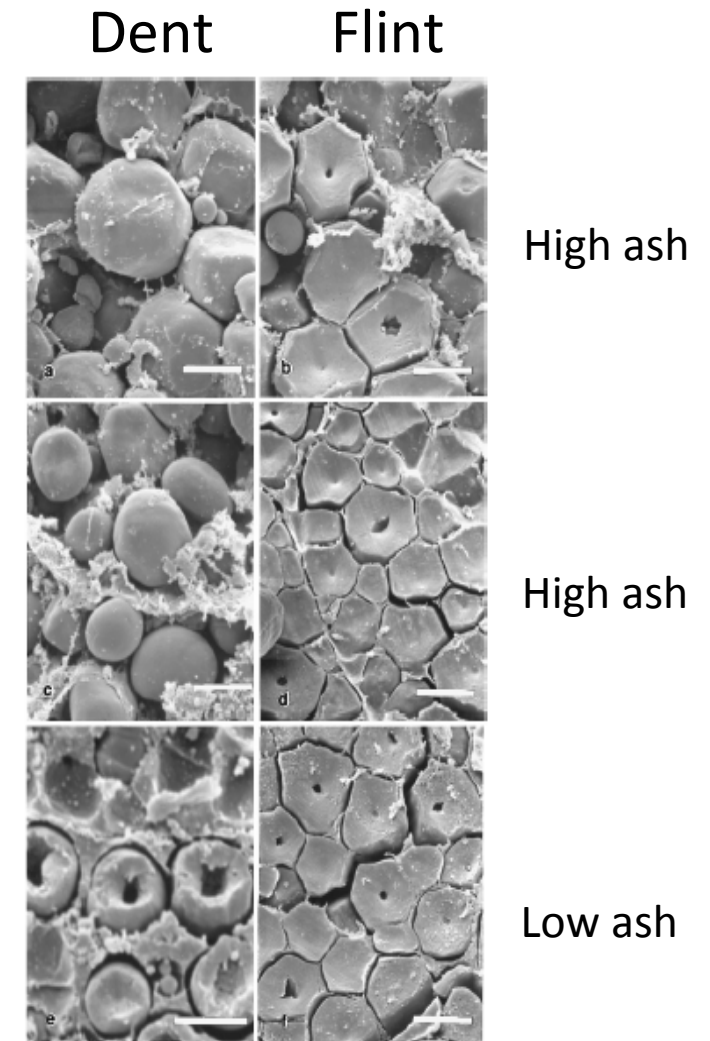
Meriem Aoun  
Marilyn Warburton et al.

# Plant breeding as a public health issue

Plant traits influence fungal colonization  
and toxin accumulation



<https://ubersuper.com/mri-scans-of-fruits-and-vegetables/>



Kereliuk and Sosulski, 1996

