

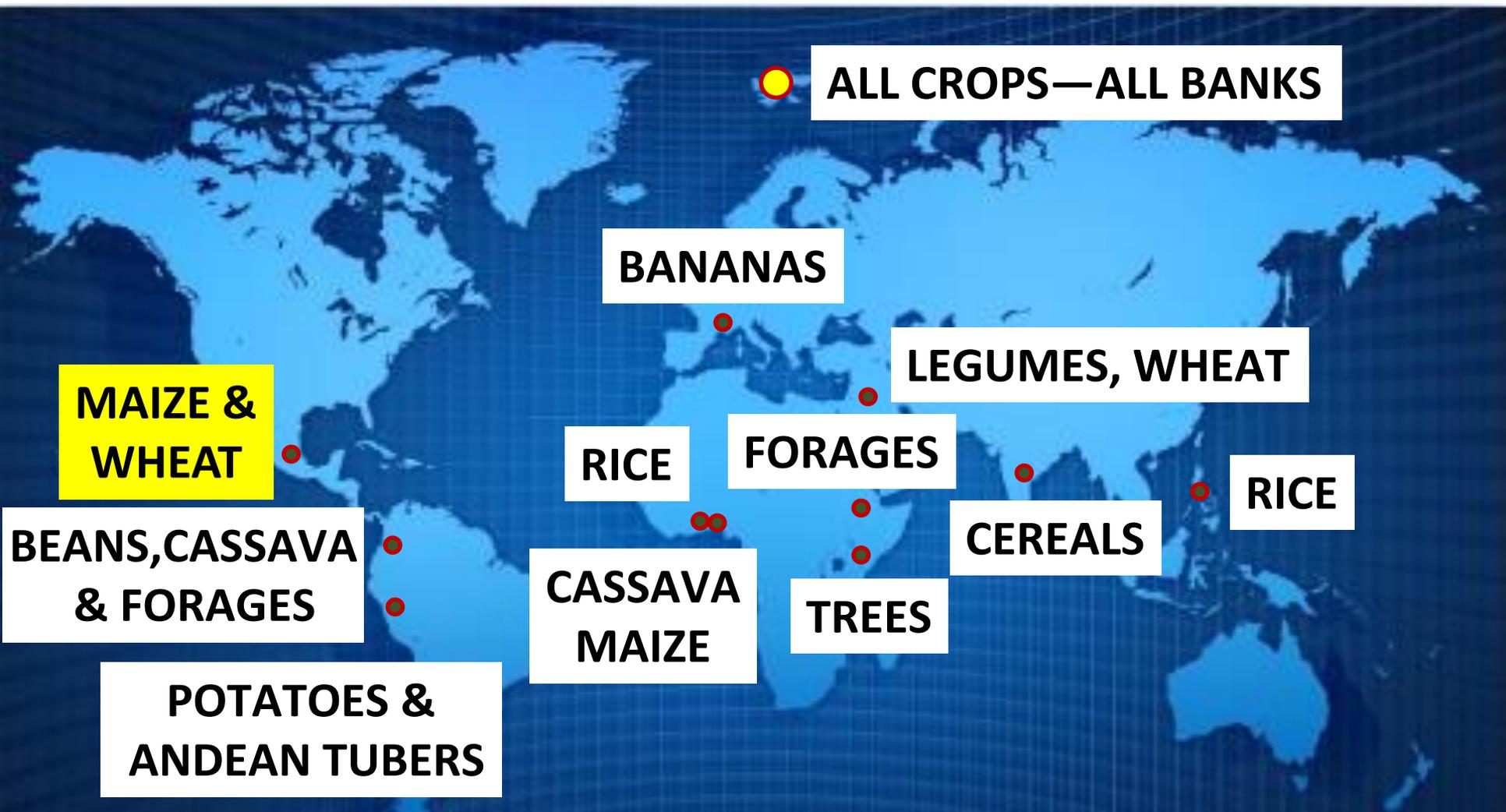
1966-2016  
CIMMYT

# Harnessing crop genetic resources to meet the challenges of feeding the world in 2050 and beyond

**Kevin Pixley & Denise Costich**

ICSC Beijing, 16 August 2016

# The “Global Goods” of the CGIAR\* Germplasm Banks



\* Consultative Group for International Agricultural Research

# Why do we preserve germplasm?

**To ensure:**

- ✓ **The survival of the genetic diversity in the world's major crop species and their wild relatives;**
- ✓ **That this essential resource remains available for use by current and future generations.**



# CIMMYT Maize & Wheat Bank

- **Largest global collections for both crops**
- **ISO Certified in 2012 and renewed in 2015**
- **Implementing GRIN-Global data management system**
- **Solar-powered refrigeration system in the vaults**



# Conservation: The Vaults

- Inaugurated in 1996
- Earthquake-proof
- Active collection @ ground level
  - Temperature = 0° C
  - Rel. humidity = 25-30%
  - Seed viability ~ 25-30 years
- Base collection (belowground)
  - Temperature = -18° C
  - Humidity not controlled
  - Seed viability > 50 years



# The work of the bank is much more...



Characterization

Germination

Testing

Studying diversity

Preparing orders

Storage

Participating in workshops

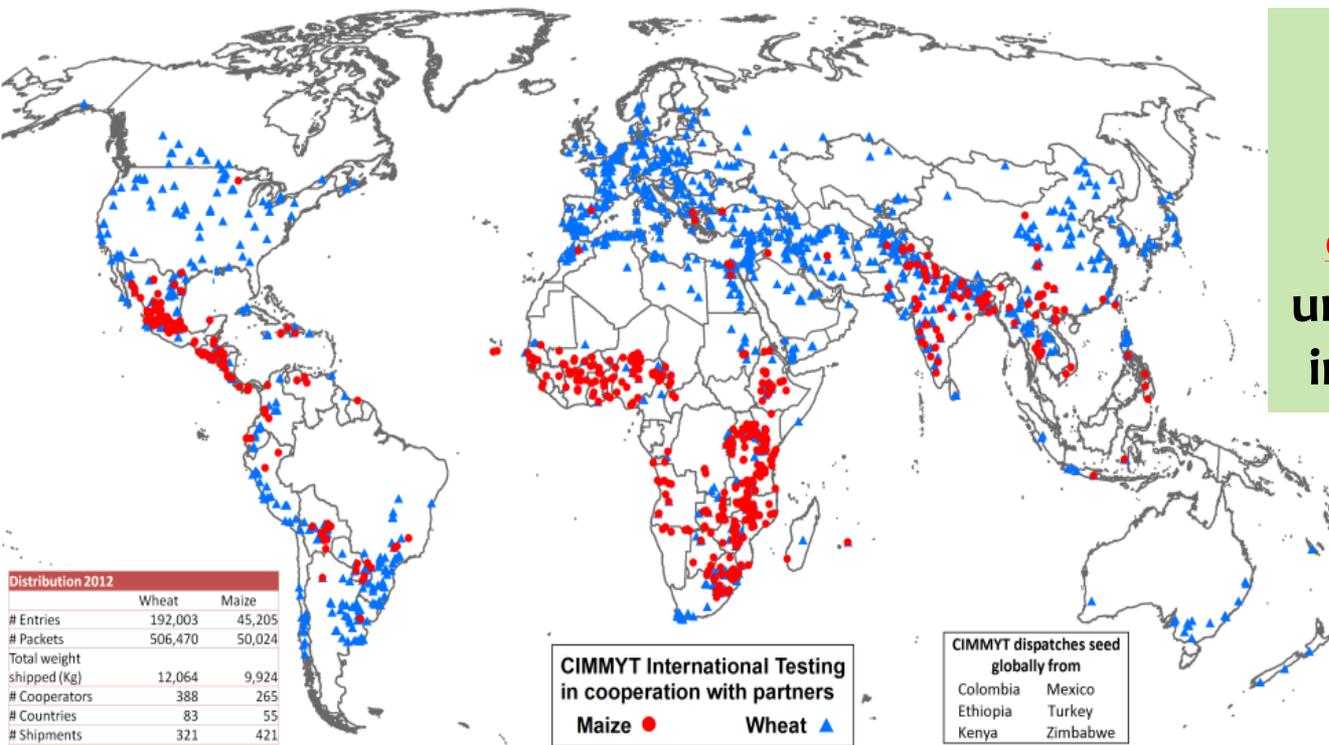
Pollinations

Regenerations



# CIMMYT: Seed shipments 2015

Maize & Wheat Distribution From Mexico (2015)	To Developed Countries	To Developing Countries	Internal, within CIMMYT
Total Packets	25,000	295,080	147,100
Percentage Packets	5%	63%	31%
Total Shipments	181	485	68
Percentage Shipments	25%	66%	9%



... since January 2007, CGIAR Centers have transferred **over 2,680,000 samples** under SMTAs to recipients in about **160 countries...\***

\*2015 CGIAR Consortium report to the Governing Body of the Treaty  
<http://www.planttreaty.org/sites/default/files/gb6w20e.pdf>



# The Global ex situ collection of Maize = 305,318 accessions in 281 banks\*

Bank	Country	%
CIMMYT	Mexico	9
NC7-USDA	USA	7
ICGR-CAAS	China	6
INIFAP	Mexico	5
VIR	Russia	3

✓ Available  
✓ for use

\*FAO 2010. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture. Appendix 2, Table A2

# On-line:

- ✓ Information about the collection
- ✓ Instructions for ordering seed

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## CIMMYT-Maize Germplasm Bank 1.9.4



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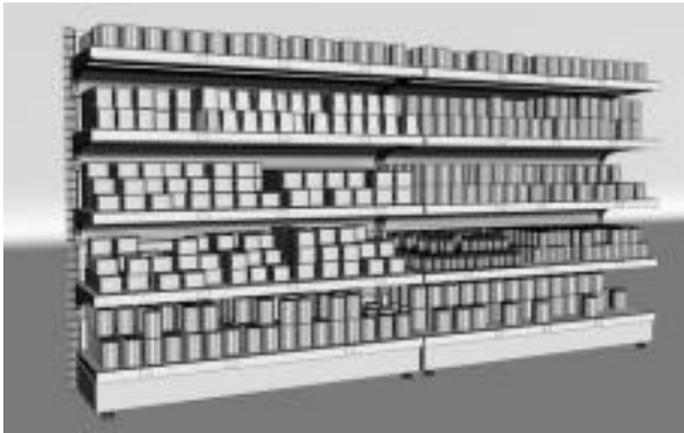
<http://mgb.cimmyt.org/gringlobal/search.aspx>  
<http://www.cimmyt.org/obtainseed>





# Seeds of Discovery (SeeD)

Vision: Genebanks used effectively



Before SeeD

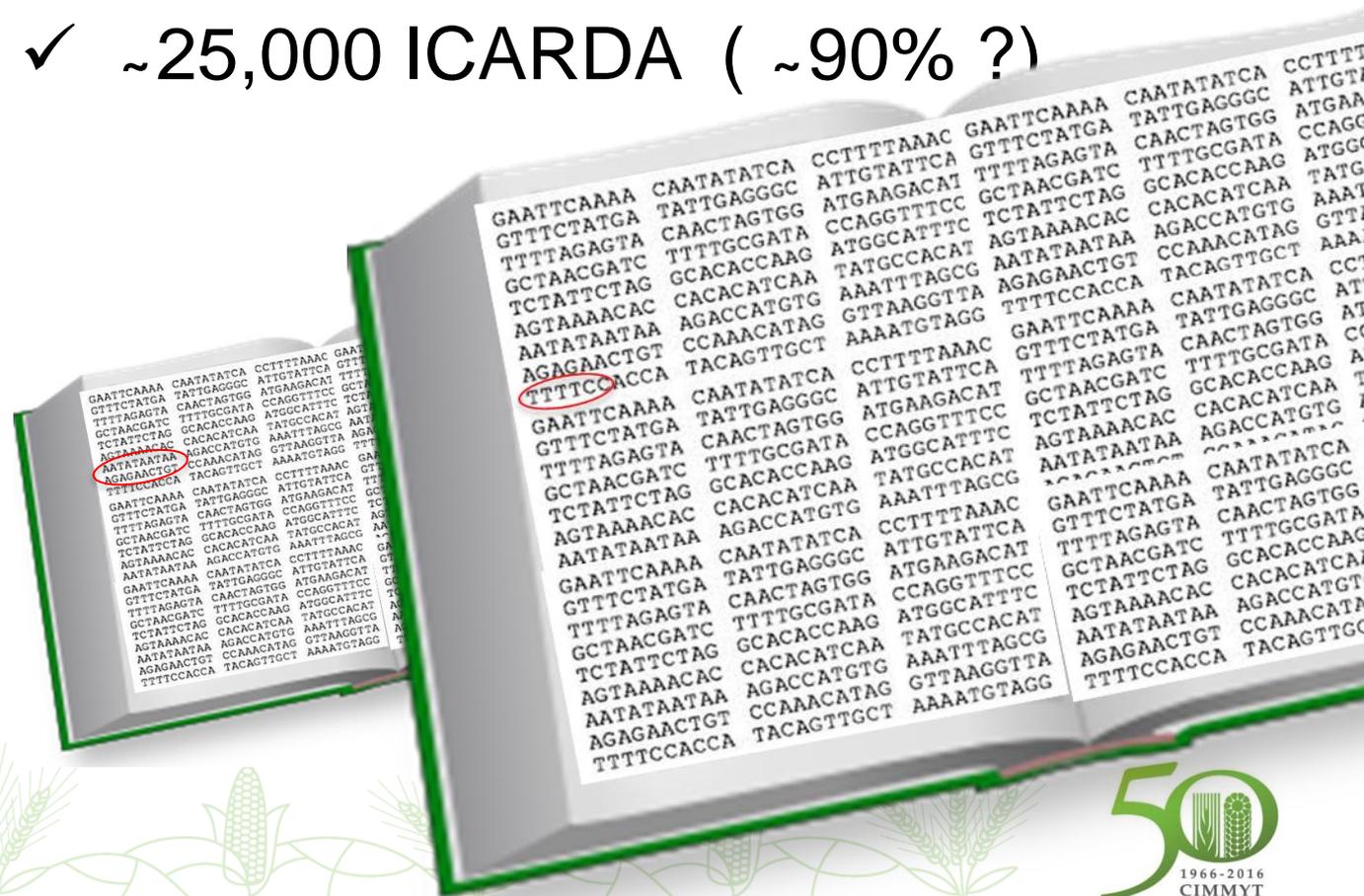


With SeeD



# SeeD – high-density genetic profiles

- ✓ ~28,000 Maize ( ~100%)
- ✓ ~50,000 Wheat ( ~35%)
- ✓ ~25,000 ICARDA ( ~90% ?)



**Farmers with low  
yields due to  
identified stress**



**Farmers with low yields due to identified stress**



**Breeders need new sources of genetic diversity**



**Germplasm Bank has 1000s of accessions to choose from....**



**Farmers with low yields due to identified stress**



**Breeders need new sources of genetic diversity**



**Germplasm Bank has 1000s of accessions to choose from....**



**Selection to increase probability of finding useful diversity**



**Phenotypic screen of selected materials**



**Farmers with low yields due to identified stress**

**Breeders need new sources of genetic diversity**

**Stress tolerant hybrids**

**Germplasm Bank has 1000s of accessions to choose from....**

**Inbred line development**

**Selection to increase probability of finding useful diversity**

**Best 1-2% are used to develop bridging germplasm**

**Phenotypic screen of selected materials**

# Maize Lethal Necrosis, MLN = combination of two viruses:

Maize chlorotic mottle virus (MCMV)  
+ Potyvirus, e.g. Sugarcane mosaic virus (SCMV)

- MLN is an occasional and local problem in US Midwest cornbelt
- MLN has been reported in China
- It is mostly transmitted by insects
- It can be seed borne
- Recently, MLN is a serious problem in East Africa



# Finding Resistance to Maize Lethal Necrosis: A devastating virus outbreak in East Africa



**Terry Molnar examining MLN-infected plants in Naivasha, Kenya (Jan 2015) and in the first screening of genebank accessions in CIMMYT- Mexico (May 2015)**

**1000 accessions selected for virus evaluation.**

**Terry Molnar (CIMMYT-GRP/Seed) & Monica Mezzalama (CIMMYT-GRP/Seed Health Lab)**

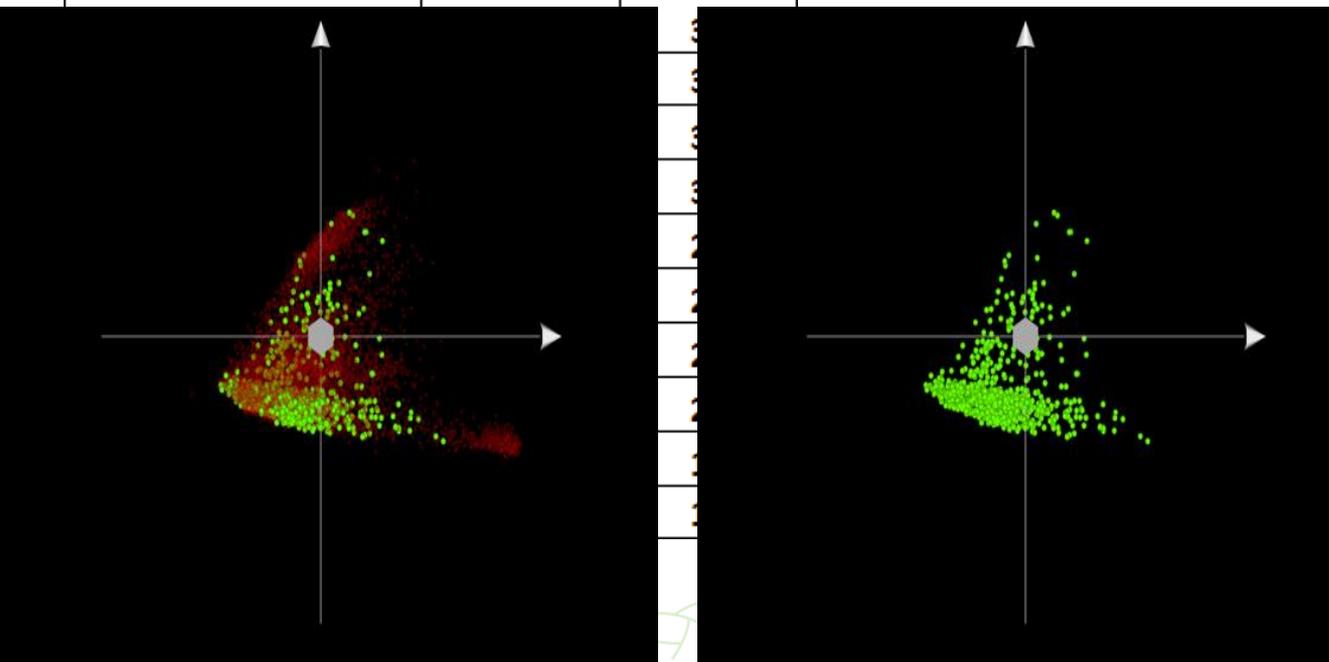


# Selection Process: Geographic, Phenotypic and Genotypic Criteria

Top Races	# of Countries	Total Access.
Tuxpeño	4	108
Tepecintle	2	53
Nal-Tel	2	48
Olotillo	1	40
Oloton	2	39
Perla	1	39

1. Sampled geographic regions most likely to have encountered the disease (and developed resistance)
2. Within each region, sampled as many maize races as possible.

3. Used genotypic data to maximize diversity while reducing to 1000 accessions.



# Phenotypic Evaluation

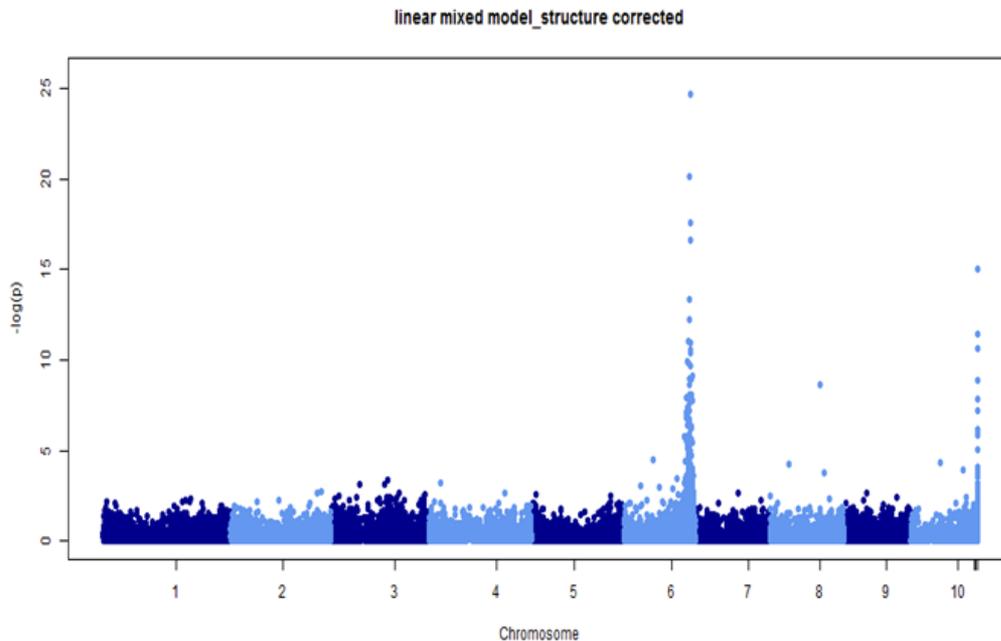
MLN

The 10 best accessions identified as having putative tolerance to MCMV, SCMV or both viruses.						
Accession	Best for	Country of Origin	Maize Race	Grain Color	Grain Type	Altitude (m)
BRVI2	MCMV	Br. Virgin Isl.	St. Croix	White	Dent	32
CUBA32	MCMV & SCMV	Cuba	Chandelle	Yellow	Dent	52
CUBA9	MCMV & SCMV	Cuba	Cuban Flint	Yellow	Flint	79
ECUA327	MCMV & SCMV	Ecuador	Cuban Yellow Dent	Yellow	Dent	5
HAIT44	MCMV & SCMV	Haiti	Haitian White	White	Flint	83
PUER15	SCMV	Puerto Rico	Coastal Tropical Flint	Yellow	Dent	15
PUER2	MCMV	Puerto Rico	Chandelle	Sun red	Dent	61
RDOM169	MCMV & SCMV	R. Dominica	Tusón	Yellow	Dent	217
VENE1014	SCMV	Venezuela	Chandelle	White	Dent	195
VERA179	MCMV & SCMV	Mexico	Tuxpeño	White	Dent	22

- ✓ After screening, went from 1000 accessions down to 20 with putative tolerance to MCMV, SCMV or both viruses.
- ✓ Have crossed and back-crossed to elite lines
- ✓ Will evaluate test-cross hybrids of BC1-S2 lines in Kenya, under MLN
- ✓ Best lines will enter breeding programs in Kenya and elsewhere

# Seeking novel sources of MLN resistance

## MLN Resistance in Maize (Kenya)



Association mapping in three populations under field conditions.

Manje Gowda & Mike Olsen

- ✓ QTL mapping in bi-parental populations
- ✓ Genotyping of resistant bank accessions
- ✓ Identify different resistance alleles
  - At same locus
  - At different loci
- ✓ Options for breeding programs
  - Native variation
  - Gene editing

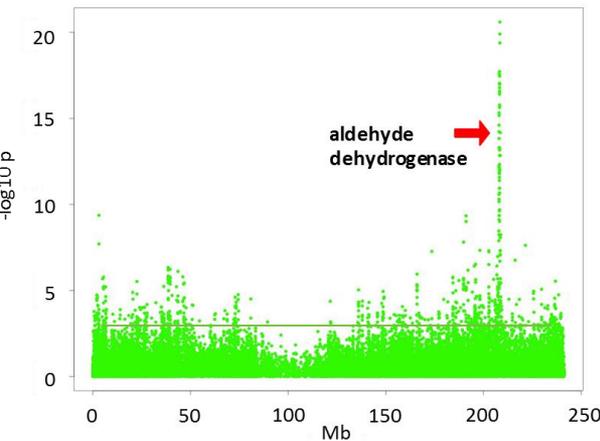


# “Environmental GWAS”: Adaptive variation

GbS from GWAS panel and ~2700 accessions

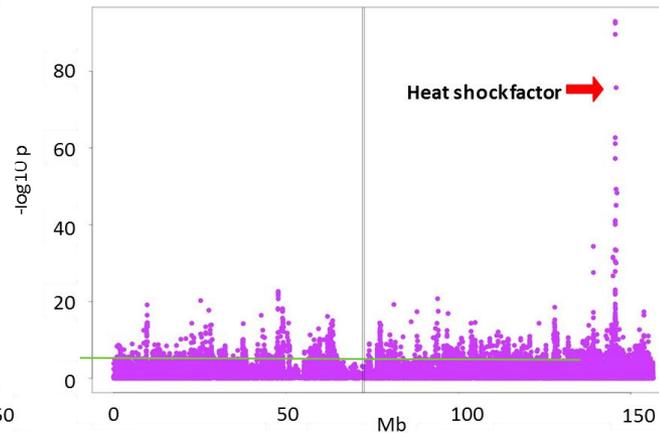
Soil pH

Chromosome 4



Precipitation 6 month season

Chromosome 9



- ✓ Preliminary analysis = Identification of candidate regions for adaptation to climatic factors of production importance
- ✓ We have >19000 accessions and many other high valuable GIS variables to apply this to 😊

Environmental traits:

Altitude  
Latitude/Longitude  
Soil waterlogging percent

**Soil pH**

**Precipitation**

Cloud Cover

Diurnal Temperature Range

Frost Day Frequency

Potential Evapotranspiration

Temperature; Monthly Average  
Daily Mean, Min and Max

Vapour Pressure

Wet Day Frequency

Aridity Index

Day length

Blue = monthly, annual and  
adjusted 6 month growing season  
and 3 months of flowering and grain  
fill

# Conclusions:

- Genetic resources – biodiversity – found in international genebanks may contain diversity that is essential to the wellbeing of future generations.
- Conserving this germplasm is hard and expensive work, and it never ends.
- The use of these genetic resources in crop improvement is likely to accelerate very quickly.
- This can only happen if these resources remain accessible to everyone in the global community.
- We cannot take these resources for granted: funding and access issues are recurring.





谢谢

Thank you  
for your  
interest!

