Seeds of Discovery / MasAgro Biodiversidad

Discovering and enabling the use of maize and wheat genetic resources

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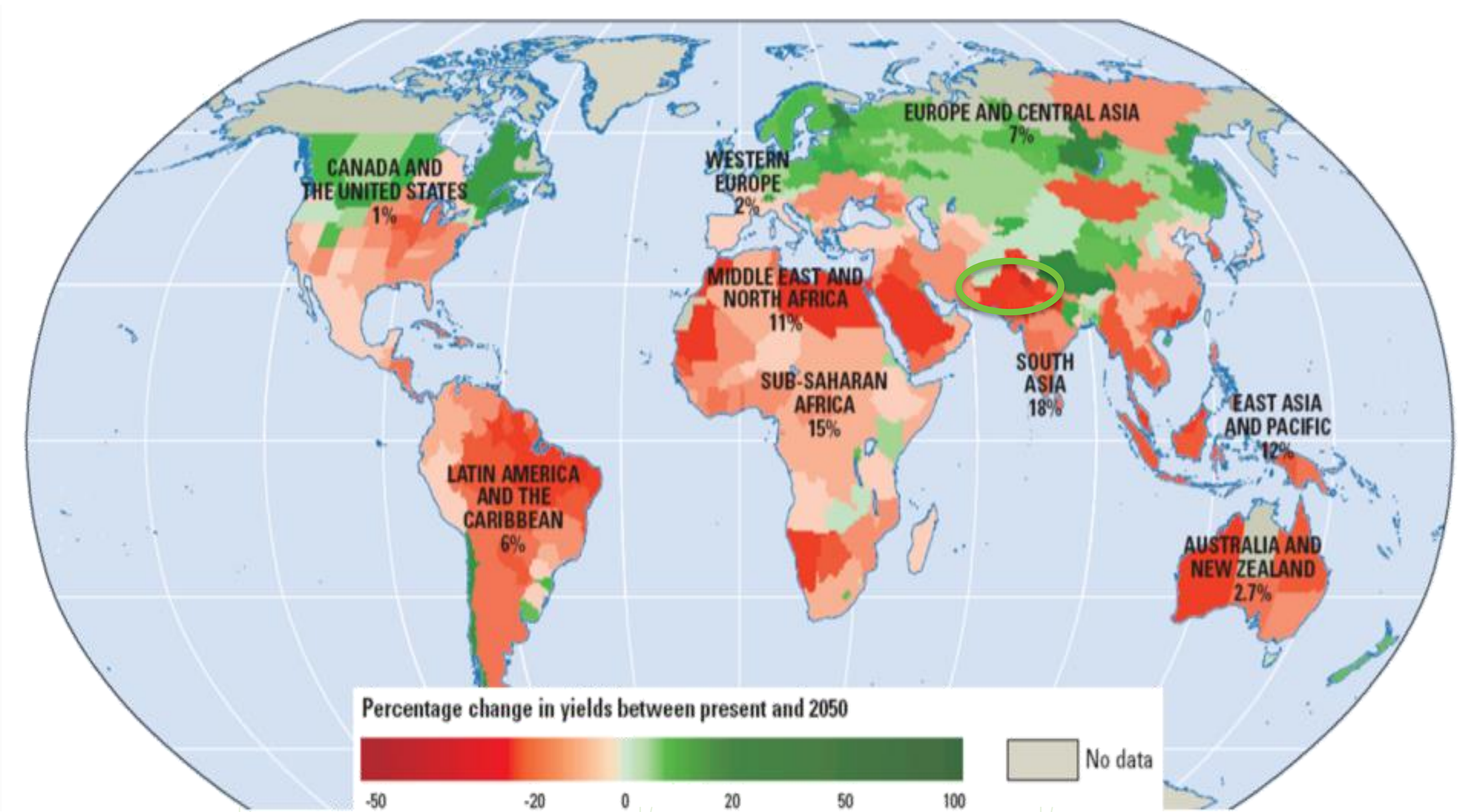
MasAgro
Modernización Sustentable de la Agricultura Tradicional

CIMMYT

"In the next 50 years we will need to produce as much food as has been consumed over our entire human history."

Megan Clark
CEO of the Commonwealth Scientific and Industrial Research Organization (CSIRO)
Australia

General scientific consensus on climate change: Tropical areas will be strongly affected (drought + heat)



Sources: Krechowicz, et. al., 2010; Lobell et al 2011

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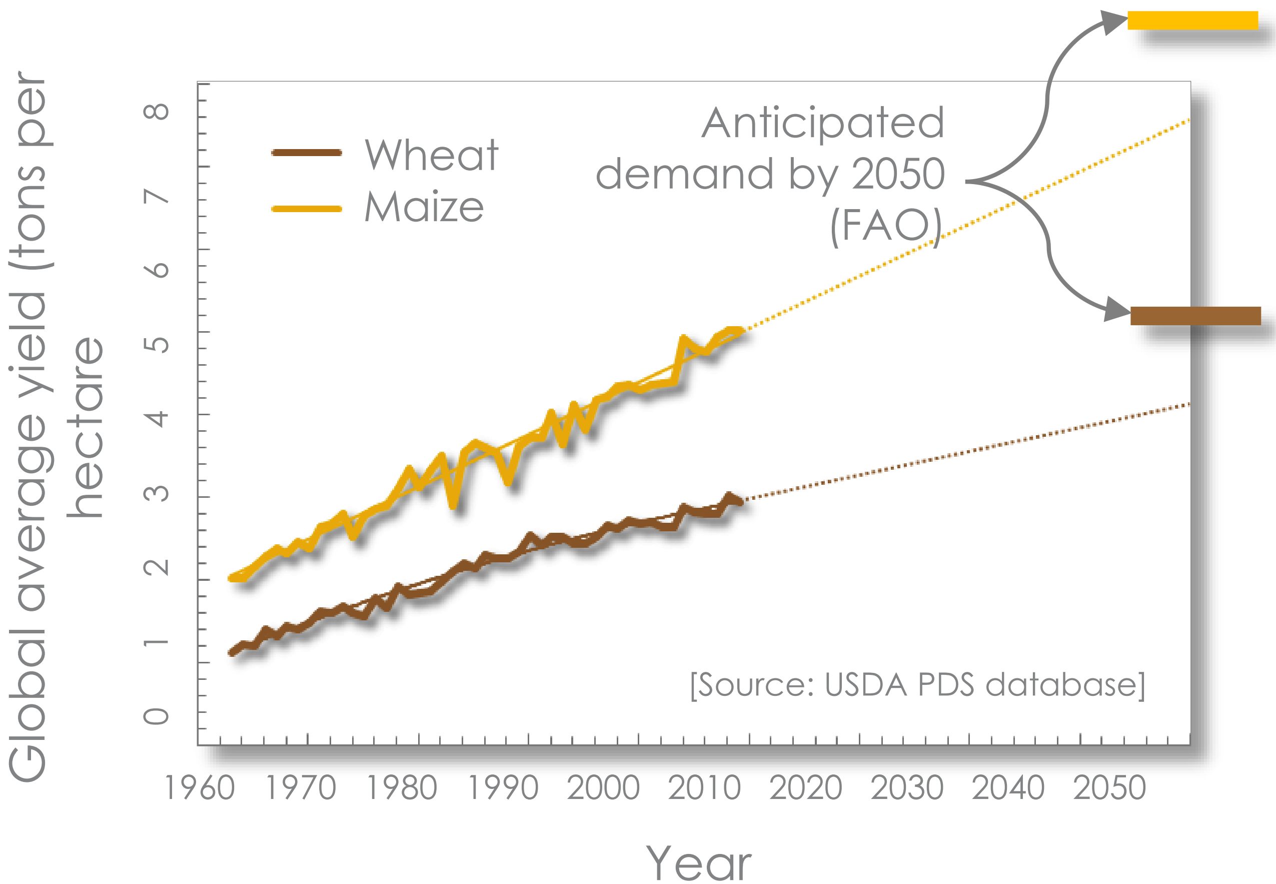
Population & demand are growing: we are not on-track for food security



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Achieving food security in view of climate change & population growth

- Current breeding materials contain only a fraction of the useful genetic variation available.
- Much of the needed diversity exists, like needles in a haystack, on the shelves of gene banks.
- Genomic tools enable us to search for useful diversity much more effectively.

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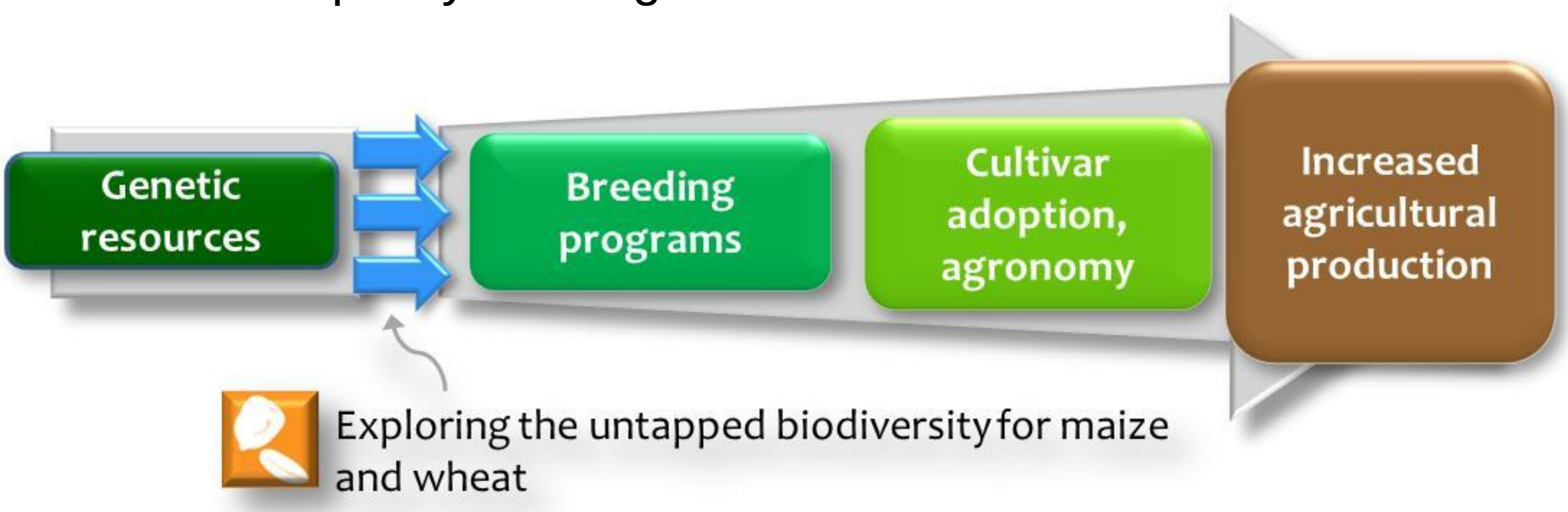
Seeds of Discovery (SeeD)
(MasAgro Biodiversidad)

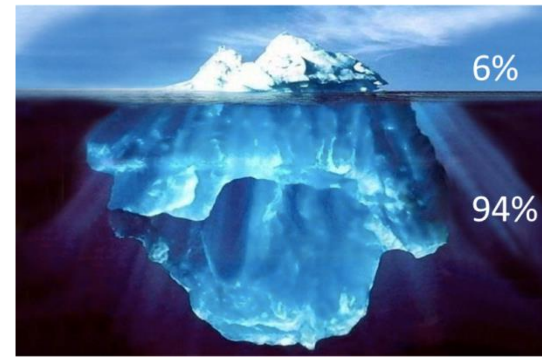
- Initiated in 2011
- Mostly funded by the Mexican government (SAGARPA)
- Four Components
    1. Molecular & phenotypic characterization → open-access database(s)
    2. Informatics Tools & knowledge extraction
    3. Bridging Germplasm
    4. Capacity building



SeeD's Vision of Success: the wealth contained in the world's genetic resources is 'unlocked' for breeders globally to make new varieties

≈ 28,000 maize

≈ 140,000 wheat

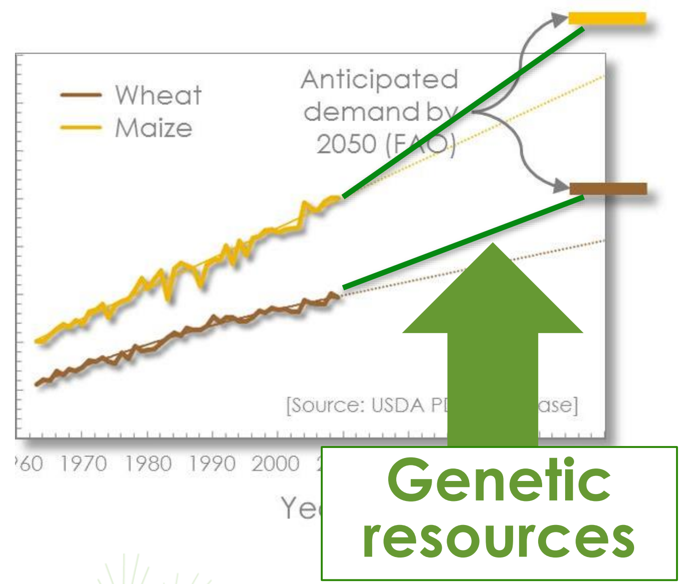


Identify useful genetic variation

Make crosses: add new to current best

Evaluate and select something better

Finalize and release a new variety



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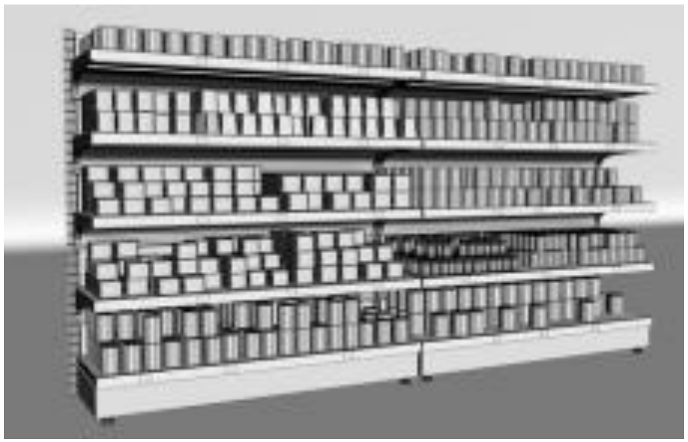
SeeD Vision: Genebanks used effectively

Before SeeD



With SeeD

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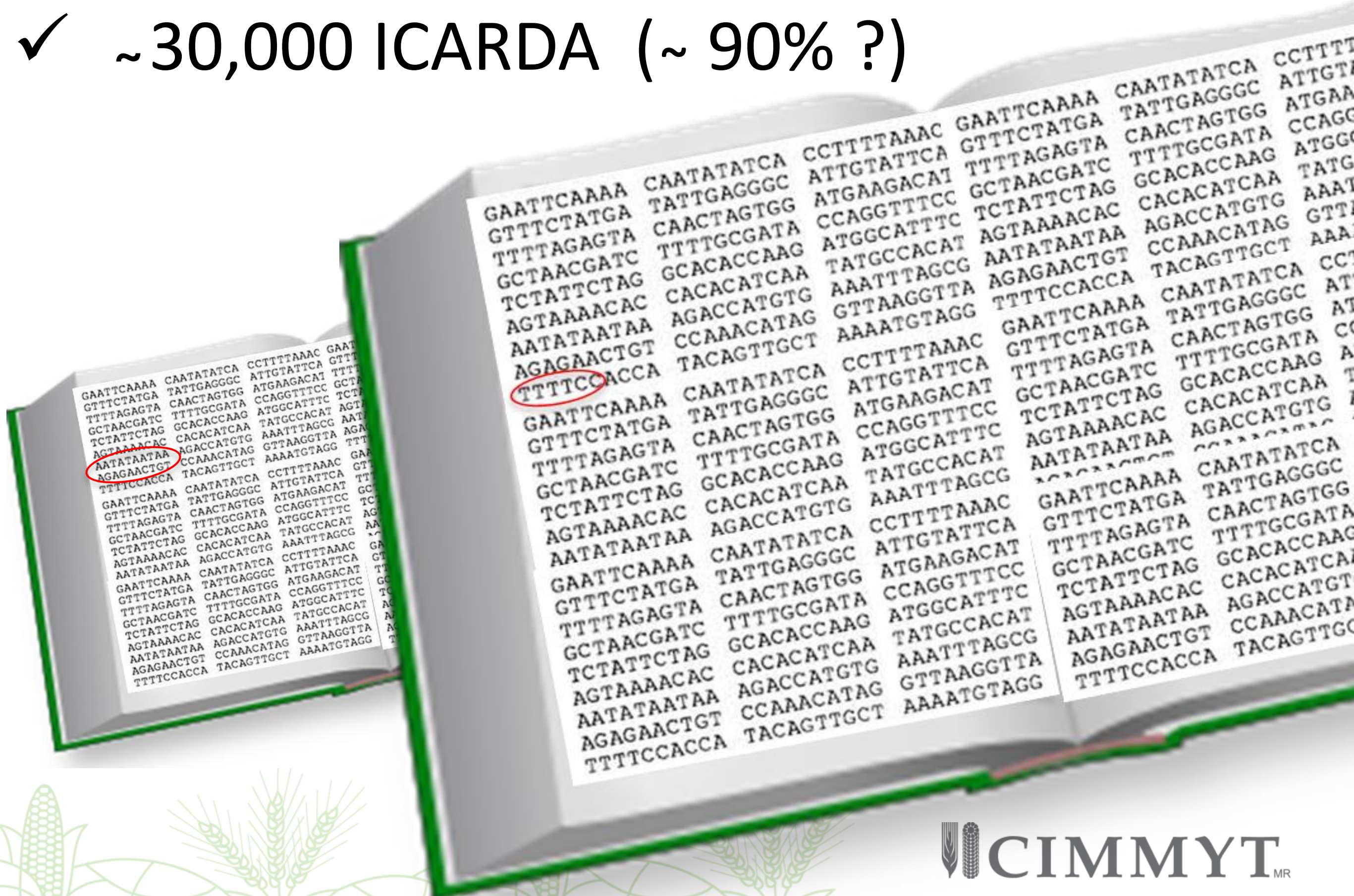
SeeD – high-density genetic profiles

- ✓ ~28,000 Maize (~100%)
- ✓ ~50,000 Wheat (~35%)
- ✓ ~30,000 ICARDA (~ 90% ?)



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98,220 wheat samples genotyped

41,345 at SAGA:

- 30,500 ICARDA accessions
- 5,640 LTP pre-breeding populations
- 3,000 landraces from Mexicali
- 2,205 wild relatives

2012	2013	2014	2015	2016

56,875 at SAGA & DArT:

- **87% hexaploid** (landraces, elite bread wheat, synthetics and prebreeding)
- **10% tetraploid** (durum, landraces)
- **3% wild relatives**

Conducting analyses using these data:

- Landrace diversity (CIMMYT & ICARDA)
- Total durum diversity
- A/B genome diversity with breadwheat, synthetics and durums
- D genome diversity with breadwheat, Ae. tauschii, etc.

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SeeD: More than 2 million measurements

Wheat	Maize
Grain yield	Grain yield
Drought	Drought
Heat	Heat
Low soil phosphorus	Low soil nitrogen
Tan spot	Tar spot
Karnal bunt	Turcicum blight
Spot blotch	Stalk rot
Wheat blast	Ear rot
Zinc	Cercospora (GLS)
Iron	Grain quality (oil…)
Protein	Carotenoids
Grain quality (twt…)	Root lodging
Phenology	Stem lodging
Morphology	Phenology

Lots of data still to analyze and extract value

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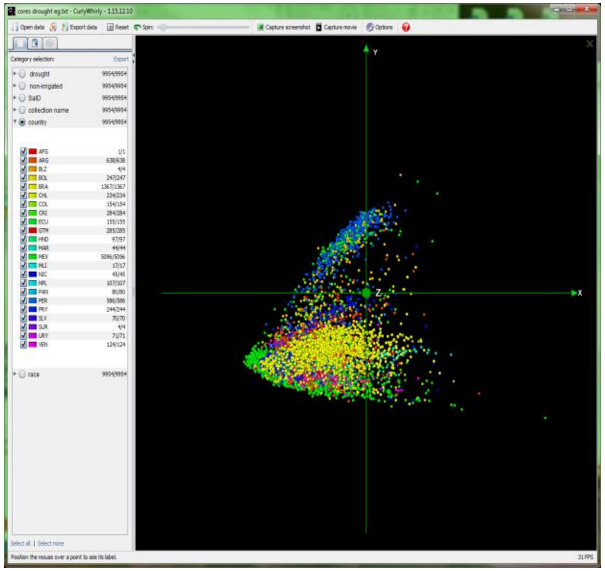
Online

Offline

GOBII

Germinate 3

Flapjack



CurlyWhirly

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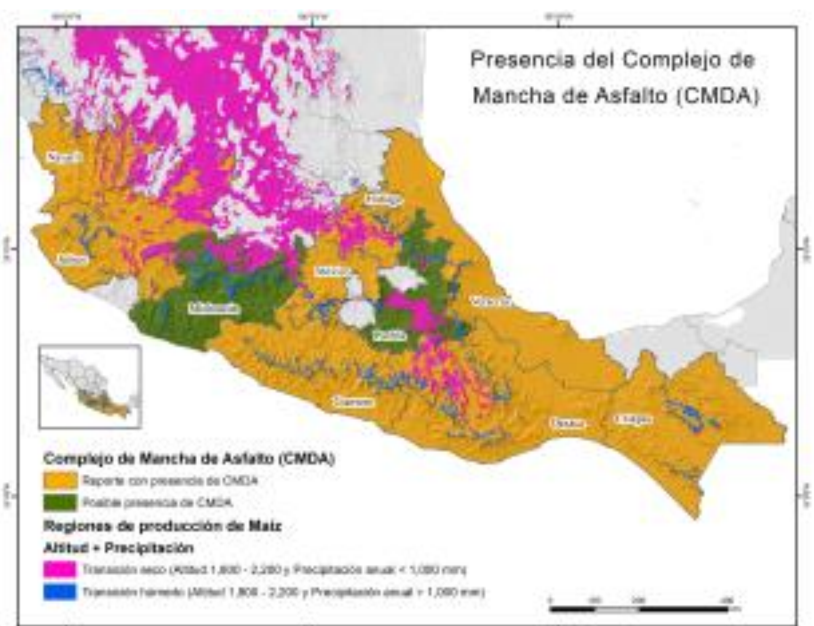
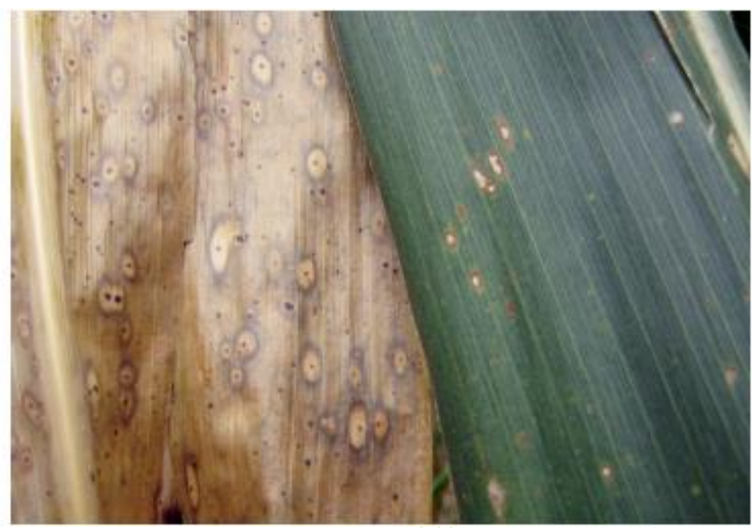
Tar Spot Disease of Maize in Mexico

- Affects >800,000 ha in 11 States… spreading.
- Causes up to 100% yield loss
- If we assume 20% yield loss on 800,000 ha
  - 1.2 Billion pesos lost





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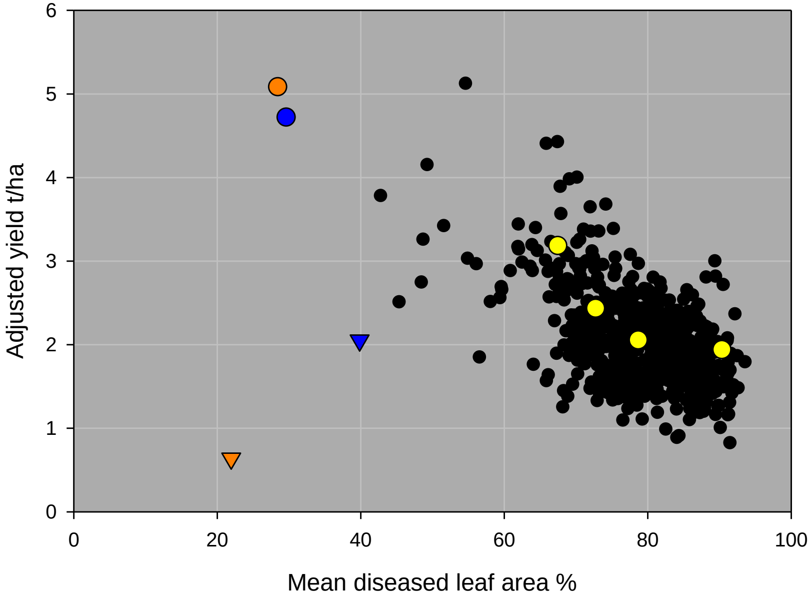
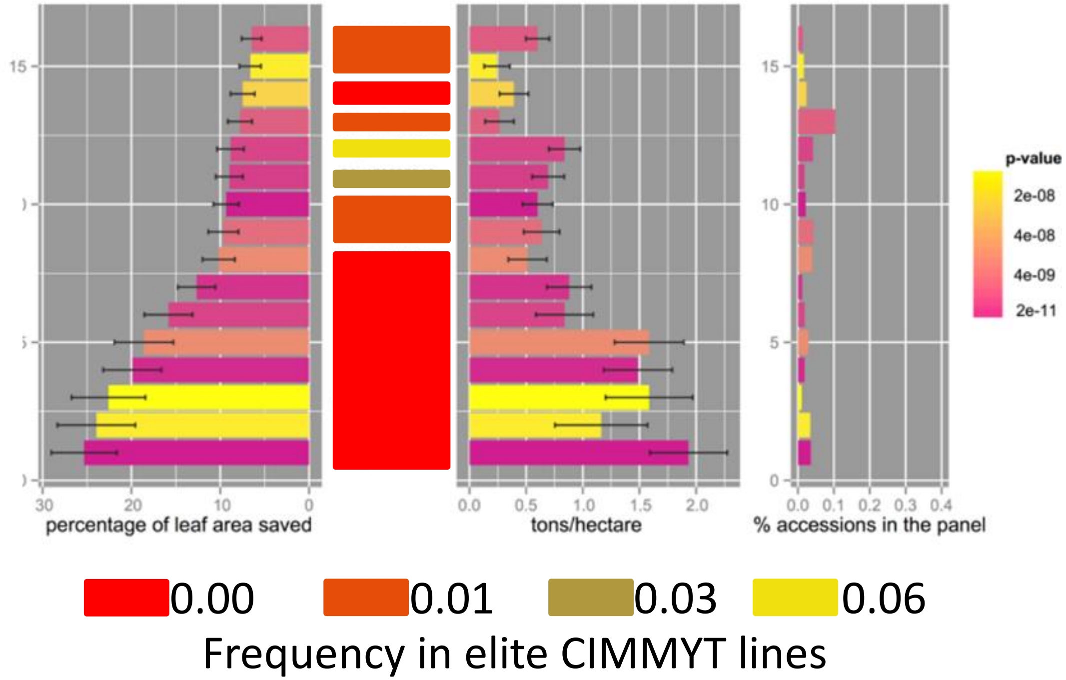
Important variation not in breeding germplasm





Novel beneficial alleles and sources identified for use in breeding

Martha Willcox et al.

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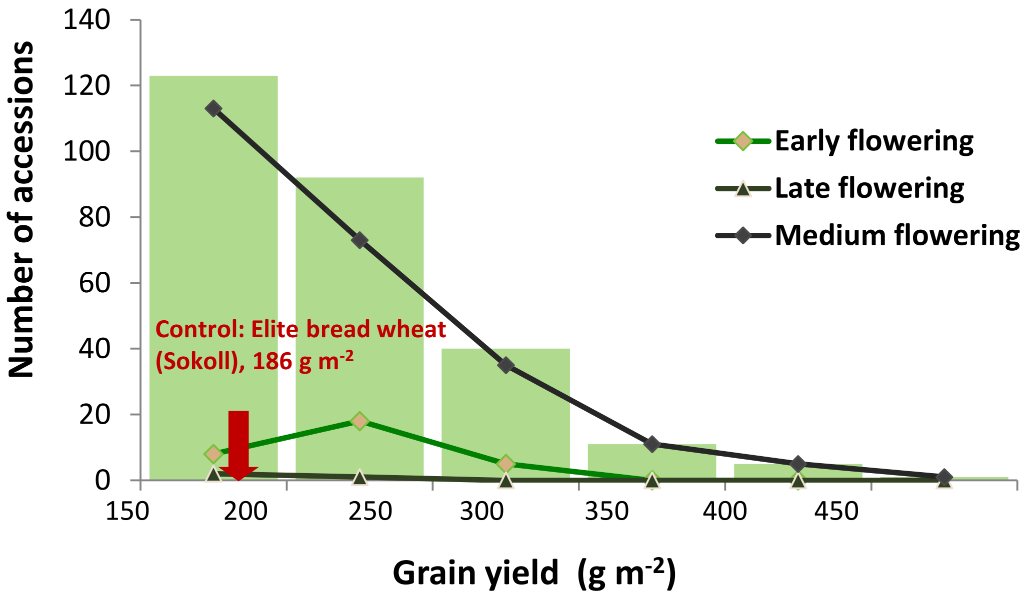
Impact of heat on wheat

- ~ 10% yield loss per 1°C increase in temperature
- By 2050, 20-30% yield loss in South Asia alone, affecting over 1 billion people

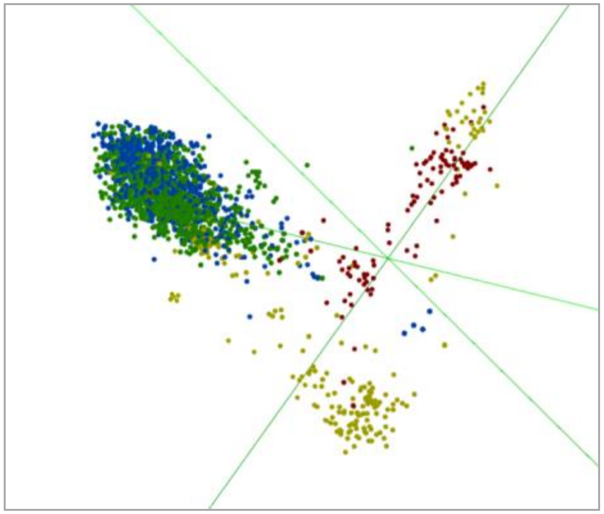
SeeD: ~70,000 wheat gene bank lines screened under heat stress (2011-2013)

Exploring Gene Bank for Heat Tolerance

Mexican landraces with grain yield >150 g m^{-2} under heat stress (Cd. Obregón, México)



PCA



- Tolerant Mexican landraces (YELLOW)
- Tolerant Iranian landraces (RED)
- Elite lines (BLUE & GREEN)

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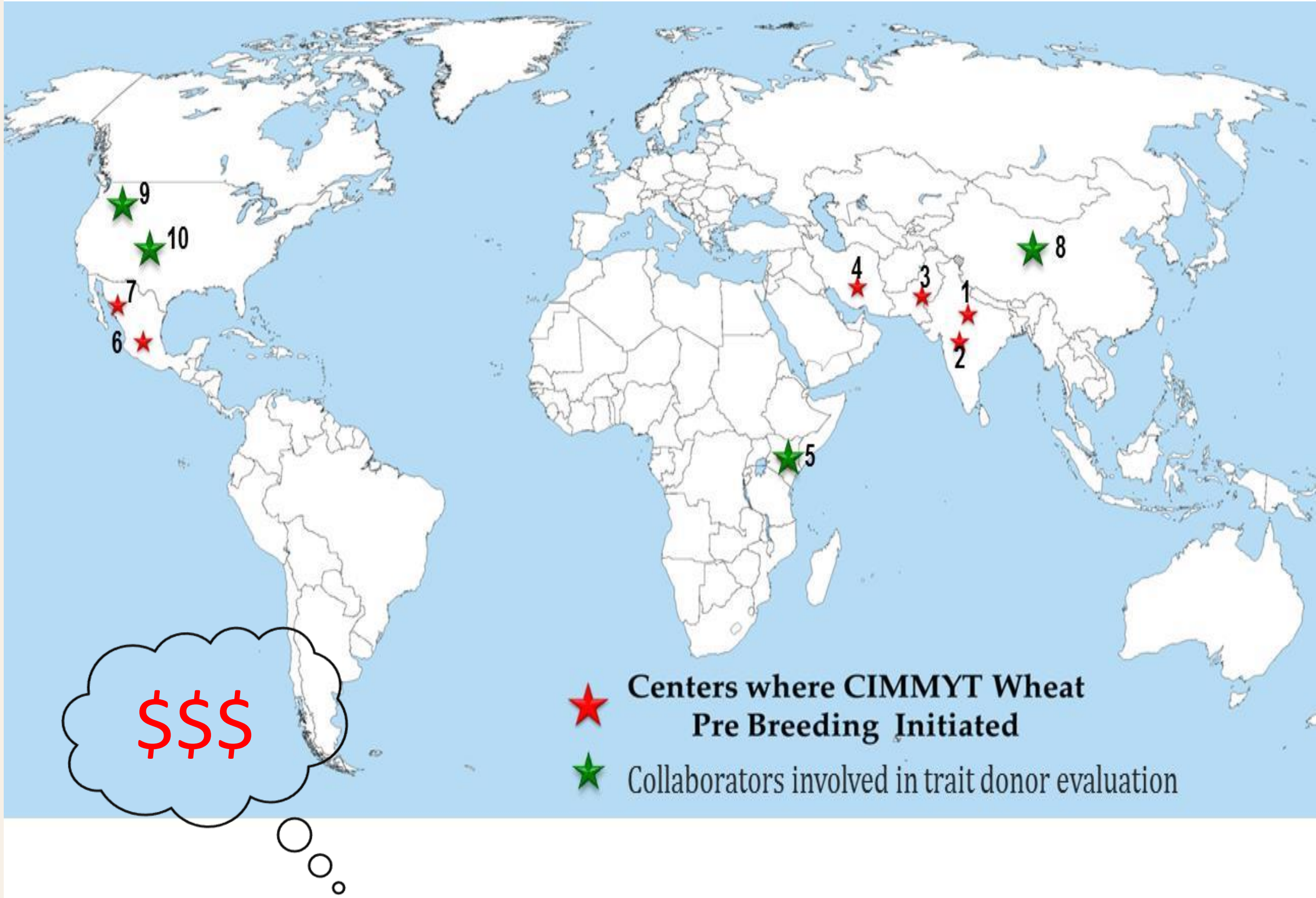
Heat & Wheat in Mexico

- 2015: heat reduced wheat yields by 1.9 t/ha in the Yaqui and Mayo Valleys
  - More than 2 billion pesos lost
- 2014: Mexico planted 615,000 ha of wheat
  - Average yield was 5.7 t/ha
  - A 10% yield loss would equate to 350,000 t, or 1.2 billion pesos

Average of 19 models for the decade of 2050 compared with long term average max temp 1951-2000

Towards a Global Wheat Pre-Breeding Platform

1. a) CIMMYT-BISA, Ludhiana
   b) PAU, Ludhiana
   c) CSK HPKV, Palampur
   d) IARI, New Delhi
2. Nat Inst of Abiotic Stress Management, Pune, India
3. Nuclear Inst of Agric, Tandojam, Sindh, Pakistan
4. Dryland Agric Res Inst, Maragheh, Iran
5. KALRO, Njoro, Kenya
6. INIFAP, México
7. Ciudad, Obregon
8. Wheat Res Inst, Acad Agric Sci, Ganzou, China
9. Washington State Univ
10. South Dakota State Univ



Scale-up required to ensure impact

Sukhwinder Singh & Co.

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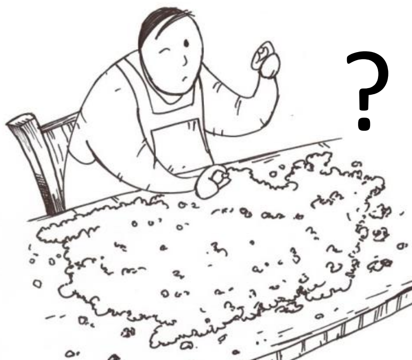
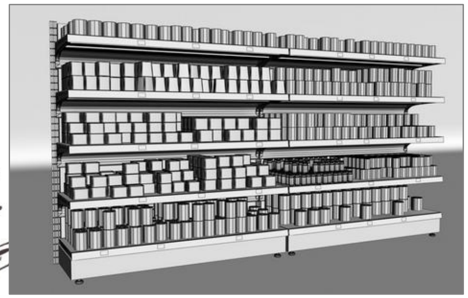
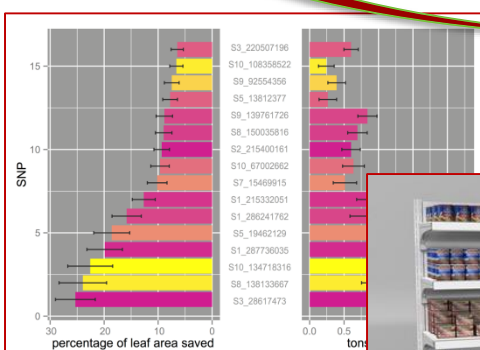
Vision: Genebanks used effectively

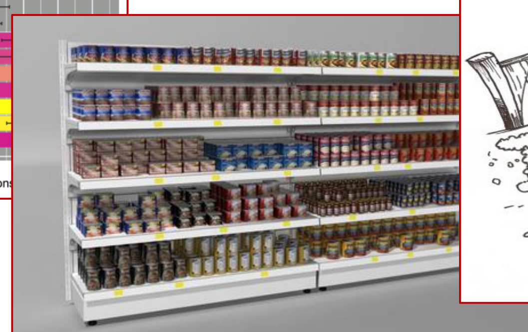




Before SeeD

With SeeD





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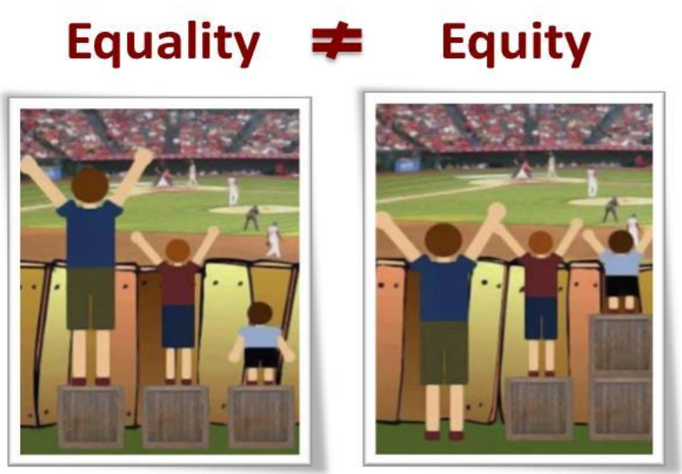
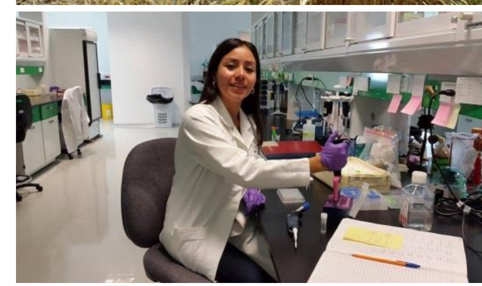
Who are the principal users of MasAgro-Biodiversidad products?

- **Breeders**: new diversity to accelerate genetic gains
  - Impact on national production
  - Impact on international commodity prices
- **Researchers**: stimulate scientific discoveries
- **Students**: a new generation of agricultural scientists
- **Professors**: curricula to train the next generation of scientists
- **Genebanks**: optimize conservation of genetic resources

Capacity Strengthening

- 238 researchers, instructors and graduate students attended courses and workshops in 2012-2015.
- 33 Ph.D., M.Sc., and B.Sc. students currently or graduated in MasAgro-Biodiversidad in the last four years.
- In 2016, at least four Mexican scientists will conduct research using datasets, tools, genotyping services and coaching from MasAgro-Biodiversidad.





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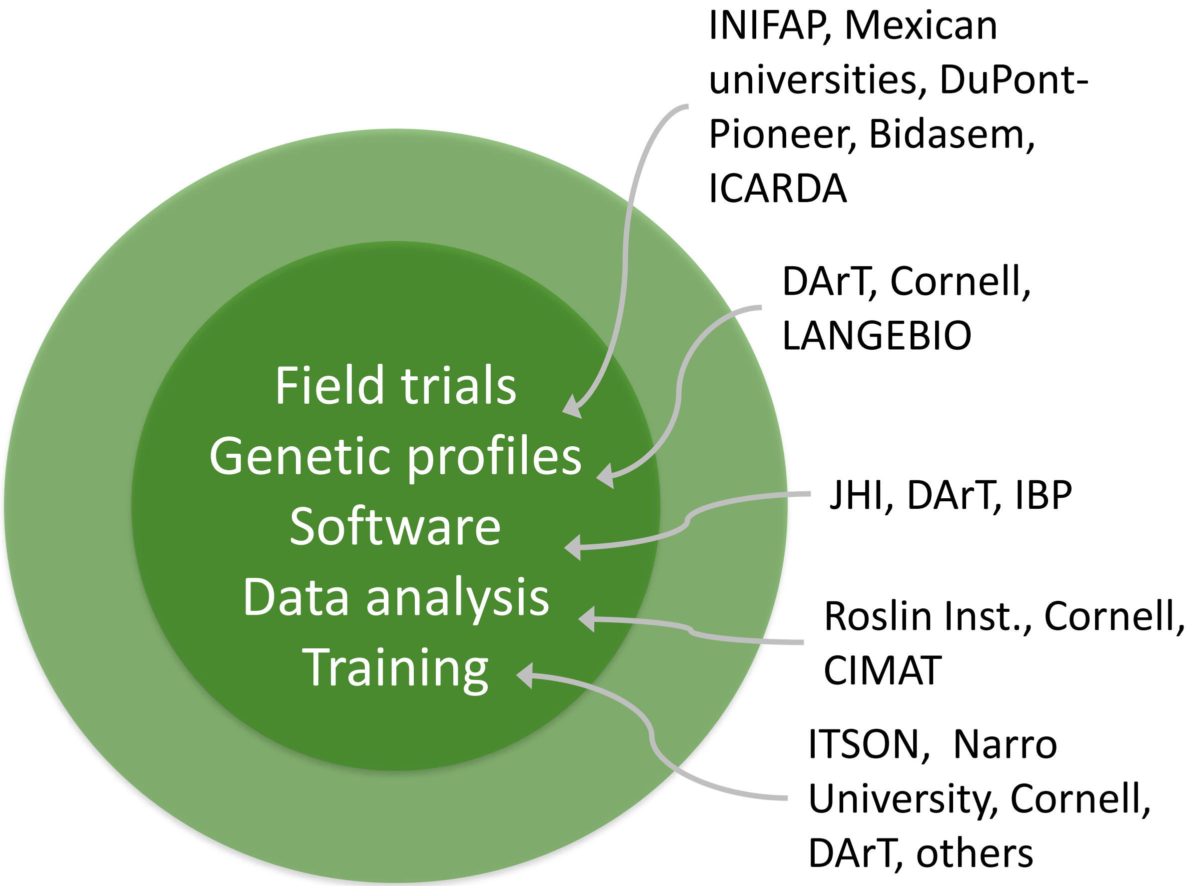
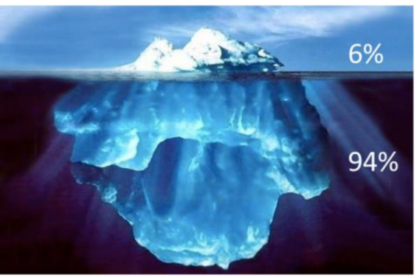
Partners

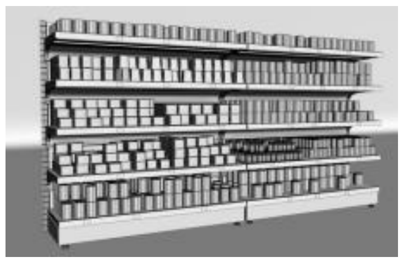


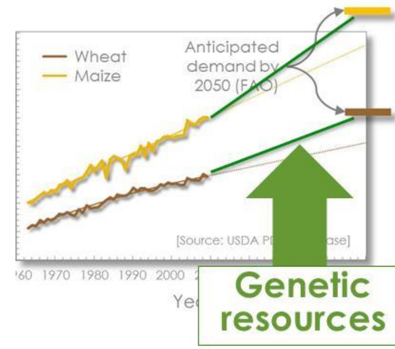
Institution	Grants
INIFAP	61
UAAAN	5
CINVESTAV	5
UdeG	2
ICAMEX	2
Chapingo	1
UAEM	1
Total	Mex$32.6M

What Can We Achieve?

Unleash the genetic potential of maize and wheat biodiversity to contribute to **producing more & better food on the same land, with similar or less resources**







To more rapidly develop varieties that are:

- **Climate-resilient** (heat, drought, diseases)
- **Input-efficient** (fertilizer use)
- **Nutritious** & livelihood-enhancing

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¡Muchas gracias!

Danke

Convention on Biological Diversity (CBD); International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA); and Nagoya Protocol

- The CBD was the first international agreement regulating access and benefit-sharing (ABS). The CBD is based on the principle that Parties have the sovereign right to exploit their own resources.
- The International Treaty was developed at the request of the negotiators of the CBD and is in full harmony with the CBD. The CBD regulates ABS on a bilateral basis. In exercising their sovereign rights, the Parties to the International Treaty have created a Multilateral System of ABS. (the SMTA)
- The Nagoya Protocol is a Protocol to the CBD and can be regarded as an elaboration of the ABS provisions in the CBD.

Jarett Abramson

Country Profiles

<u>Only</u> USA, Somalia, Iraq and Andorra have not signed CBD

<u>Note</u>: Mexico is not an International Treaty member, therefore:

- ✓ Nagoya Protocol – YES
- ✓ SMTA - NO

= Treaty: www.fao.org/Legal/TREATIES/033s-e.htm

= CBD not Treaty: www.cbd.int/convention/parties/list

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