The MAIZE & WHEAT GERMPLASM BANK of CIMMYT:

PROMOTING THE CONSERVATION, USE and STUDY OF DIVERSITY

Denise E. Costich and Tom Payne

Co-Heads, Maize & Wheat Collections

The International Maize and Wheat Improvement Center

V Congresso Brasileiro de Recursos Genéticos • Fortaleza,Ceara, Brasil
6-9 November 2018

CIMMYT

International Maize and Wheat Improvement Center/ Centro Internacional de Mejoramiento de Maíz Y Trigo

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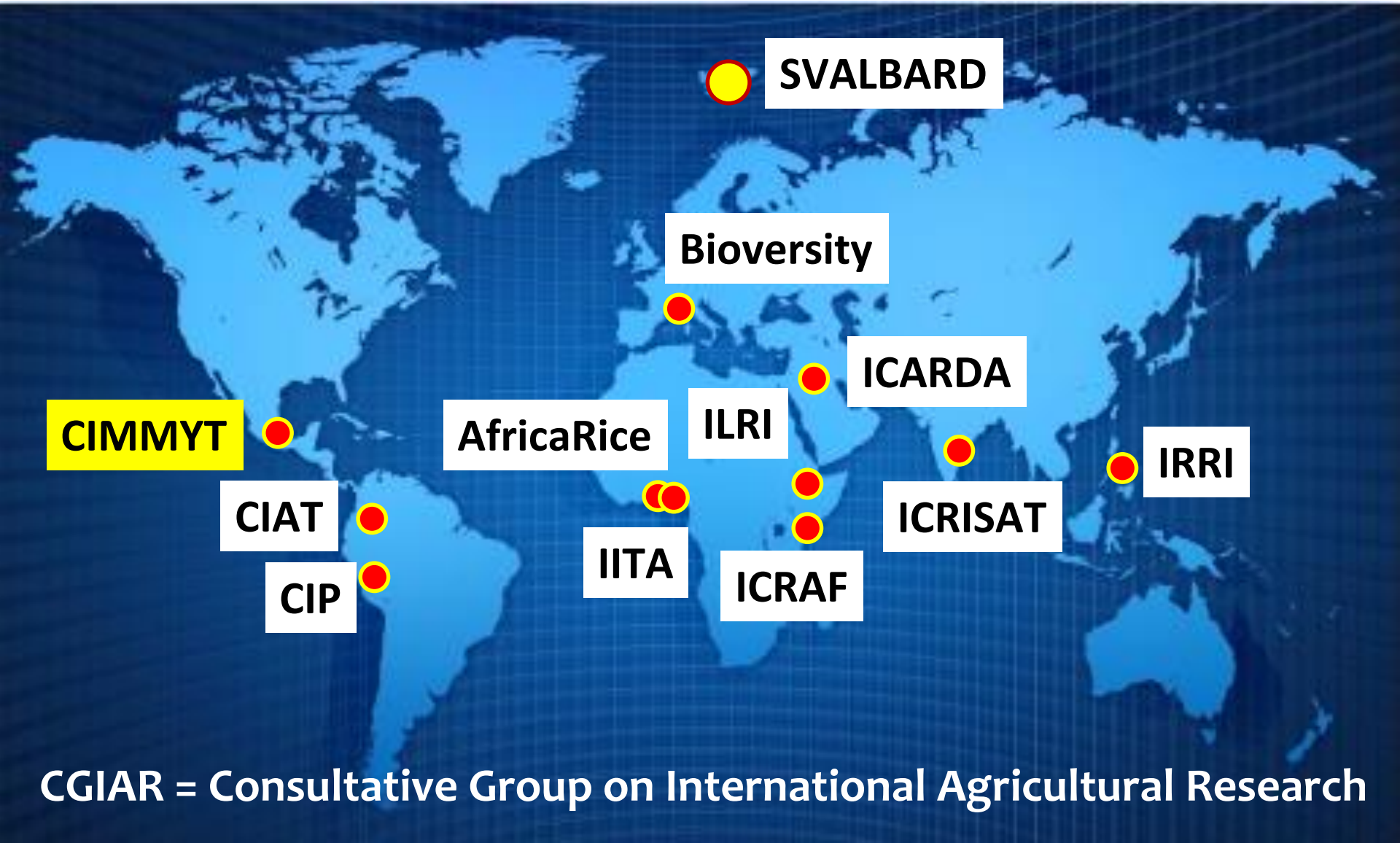
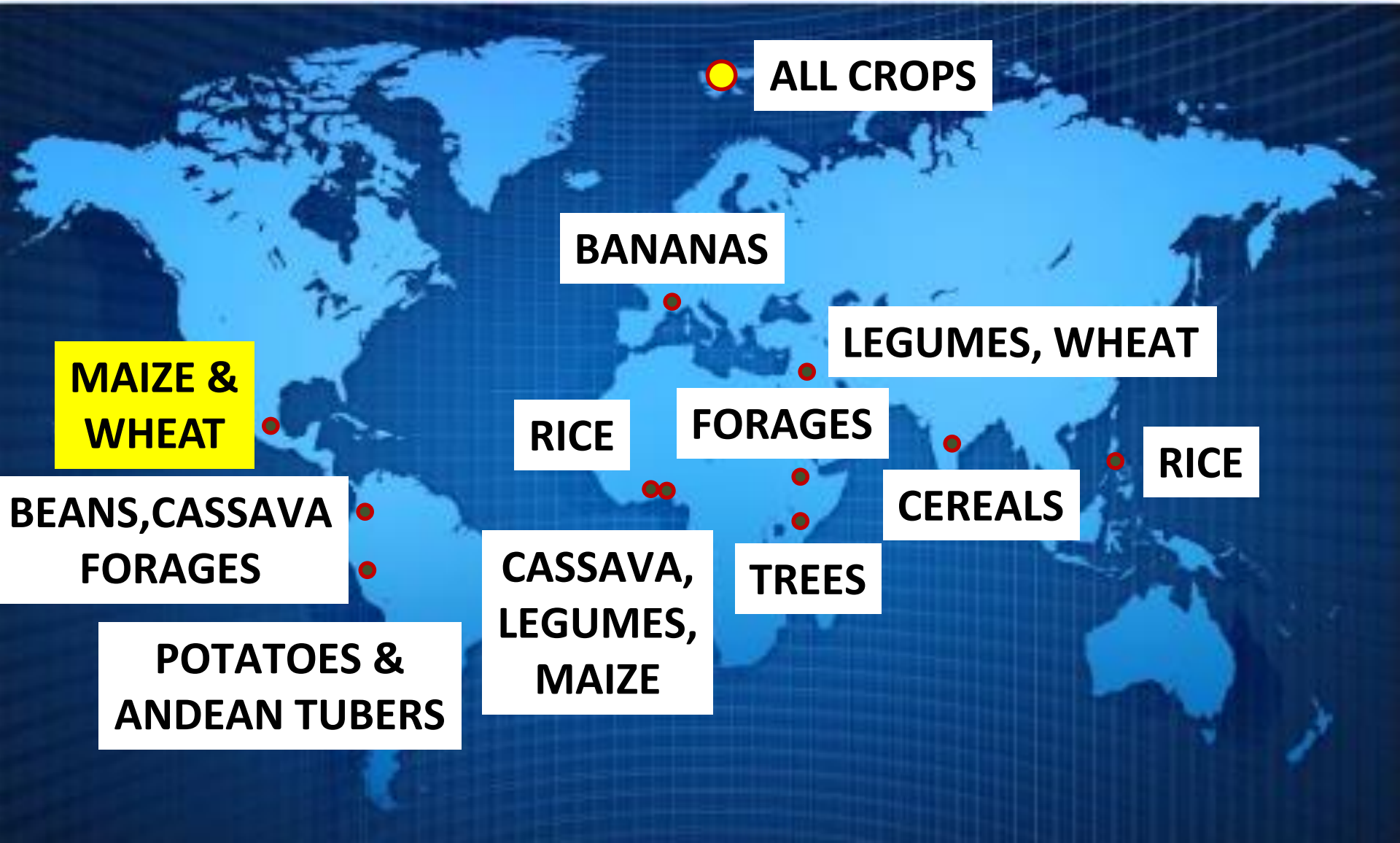
CIMMYT Germplasm Bank

Member of the global network of international germplasm banks



CGIAR = Consultative Group on International Agricultural Research

The “Global Goods” of the Network



What does all this add up to?

…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

CIMMYT

Global Genetic Resources of Maize (The "Top 5"-- >10K accs)

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

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

CIMMYT

The Global *ex situ* collection of Maize

Only ~49 K are available to all

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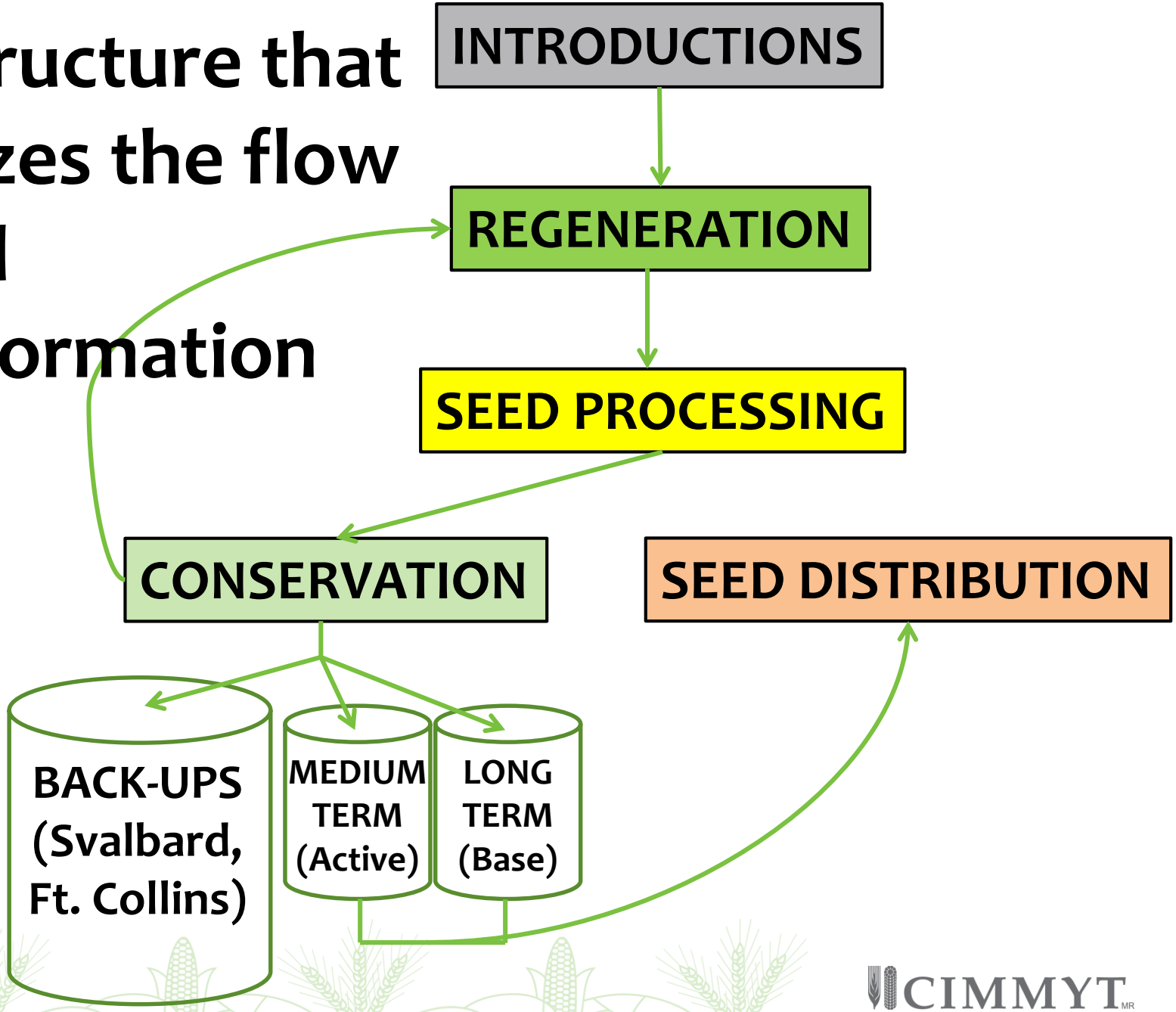
CIMMYT Maize & Wheat Bank

- Largest global seed collections for both crops
- ISO Certified in 2012, renewed in 2015, currently upgrading to ISO9001:2015
- Fully implementing GRIN-Global data management system
- Green Power: Solar-powered refrigeration system in the vaults

CIMMYT

Infrastructure that organizes the flow of seed and information



CIMMYT

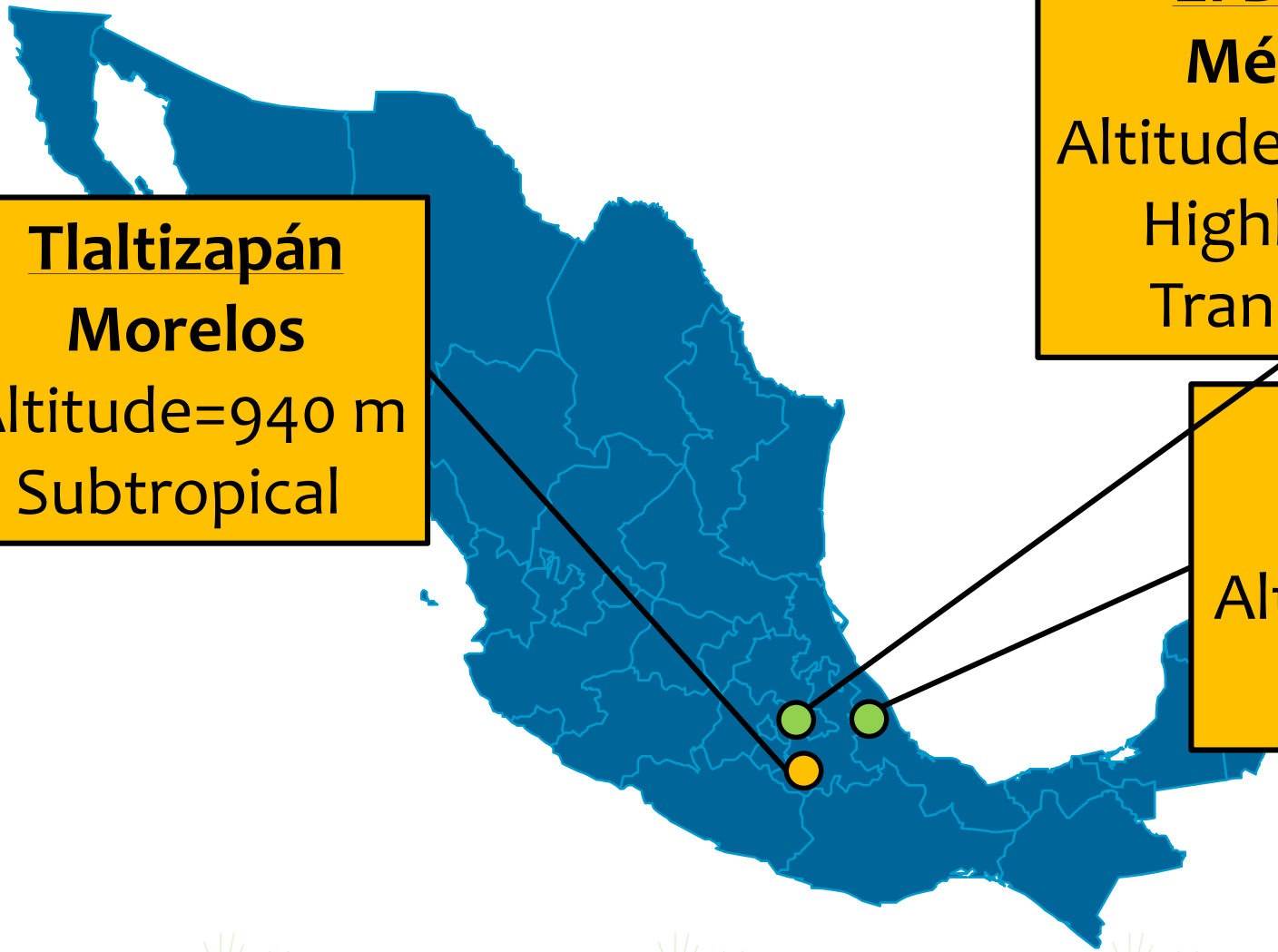
REGENERATION

- 4-5 cycles/year in 3-4 agroenvironments
- We regenerate an accession when—
  - The quantity of seed is <500 gm
  - The germination rate is <85%
- Controlled pollinations ("plant to plant")
- 80-100 healthy ears = successful regeneration





REGENERATION



El Batán
México
Altitude=2249 m
Highlands-Transition

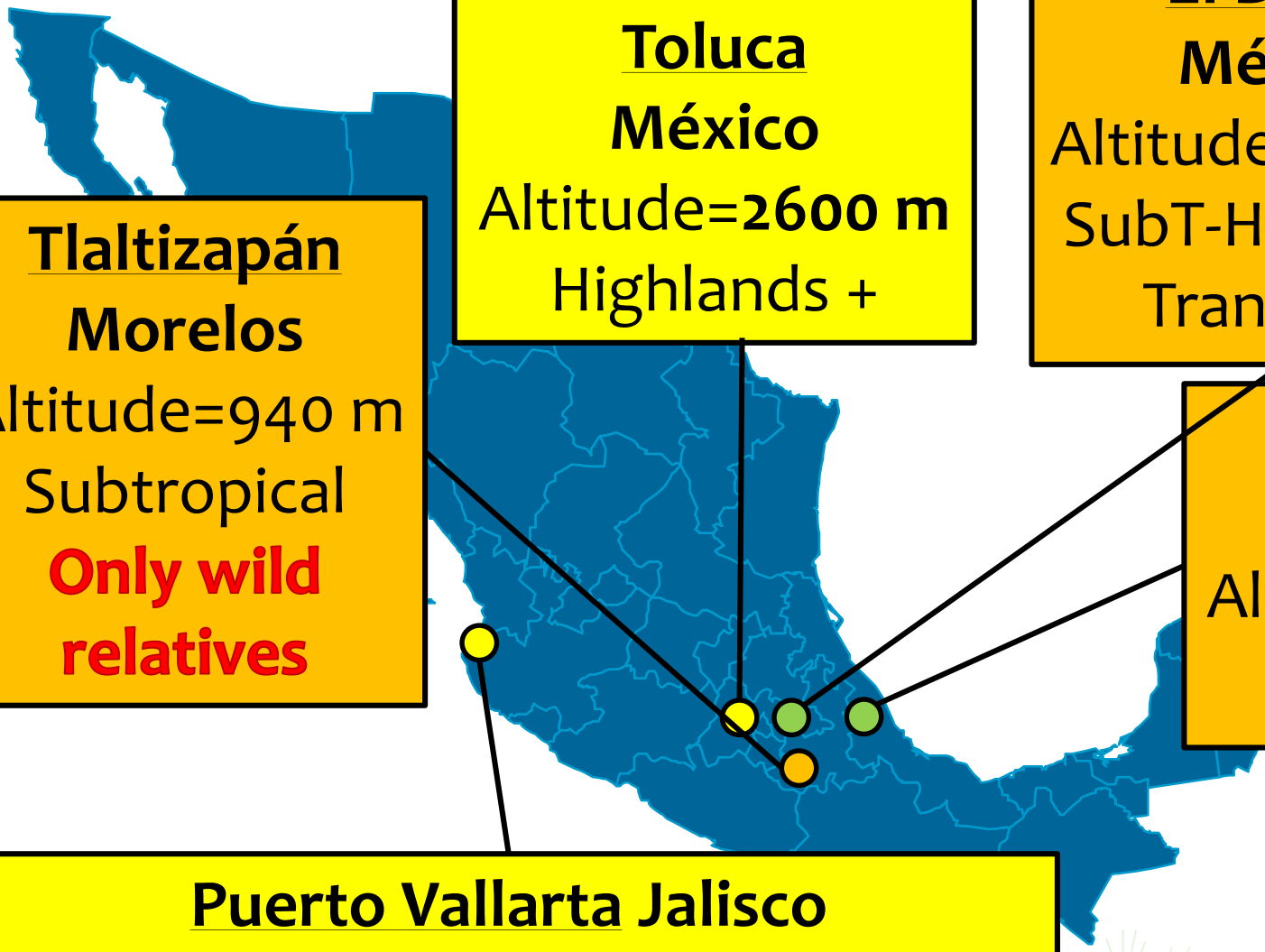
Tlaltizapán
Morelos
Altitude=940 m
Subtropical

Agua Fria
Puebla
Altitude=60 m
Tropical

2012

CIMMYT

REGENERATION



Toluca
México
Altitude=**2600 m**
Highlands +

El Batán
México
Altitude=2249 m
SubT-Highlands
Transition

Tlaltizapán
Morelos
Altitude=940 m
Subtropical
Only wild relatives

Agua Fria
Puebla
Altitude=60 m
Tropical

Puerto Vallarta Jalisco
Altitude= 0 m Winter (irrigated)

2018

CIMMYT

Information about our seed is available online via GRIN-Global

http://mgb.cimmyt.org/gringlobal/search.aspx

CONSERVATION

CIMMYT

Information about our seed is available online via GRIN-Global

http://wgb.cimmyt.org/gringlobal/search.aspx

CONSERVATION

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Studying our Diversity, Optimizing the Global Collections….

- Collections (especially those with long histories, like ours) were established without a clearly defined conservation goal or mandate
- Resulted in large collections with unbalanced compositions, unrepresentative of the overall diversity
- Conceptual views to optimize collection composition are very rare, unless you do a "**diversity tree analysis**"!
- **van Treuren et al. Optimization of the composition of crop collections for *ex situ* conservation.**
- **Plant Genetic Resources 7(2): 185-193 (2009)**

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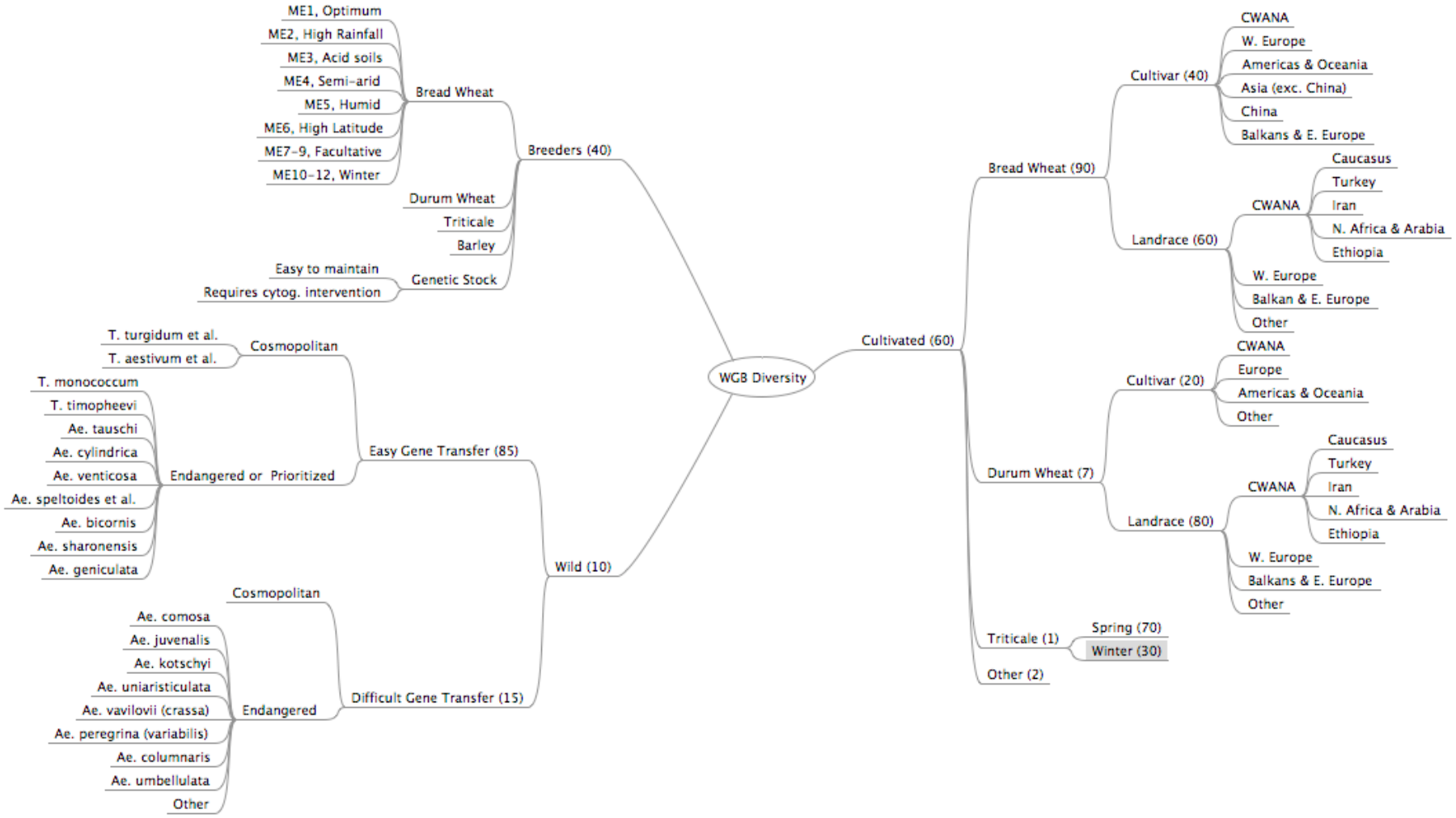
CIMMYT Wheat Diversity Tree

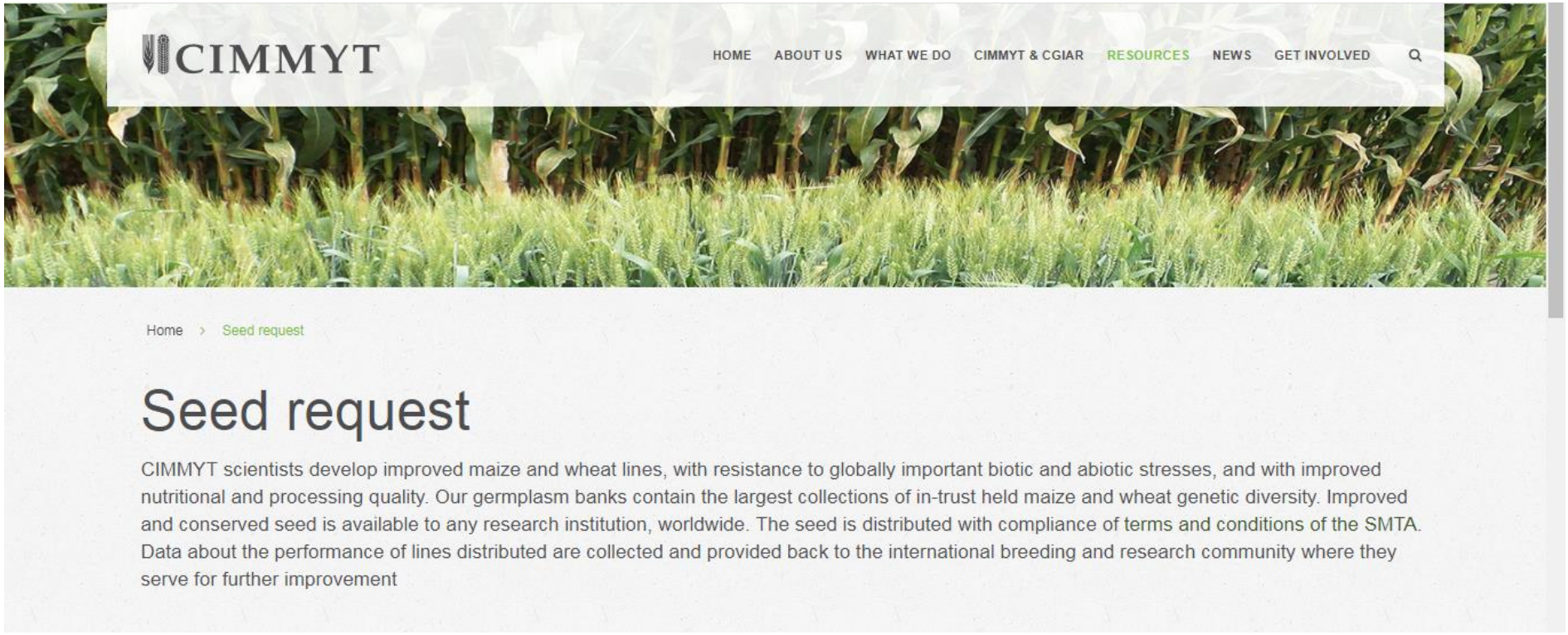


Studying our Diversity, Optimizing the Global Collections….

- Description of the content of a single collection
- Comparisons of multiple collections:
  CIMMYT (Wheat) vs. ICARDA / CIMMYT (Maize) vs IITA
- Identifying gaps and surpluses
- As a tool, for strategic phenotyping and genotyping
- Compare to ecogeographic and phylogenetic analyses
- Visualize types of materials most sought after by clients

Everyone can order seed online

http://www.cimmyt.org/obtainseed



DISTRIBUTION

CIMMYT

Distribution in 2016
Maize Collection-CIMMYT

Available accessions	**28,339**
Internal Distribution	**1570**
External Distribution	**5769**
Unique accessions distributed Total number (% of the collection)	**3713** **(13.1%)**

CIMMYT Researchers & Breeders ● International & National Ag Research Institutes ● University Researchers ● Educators ● Farmers

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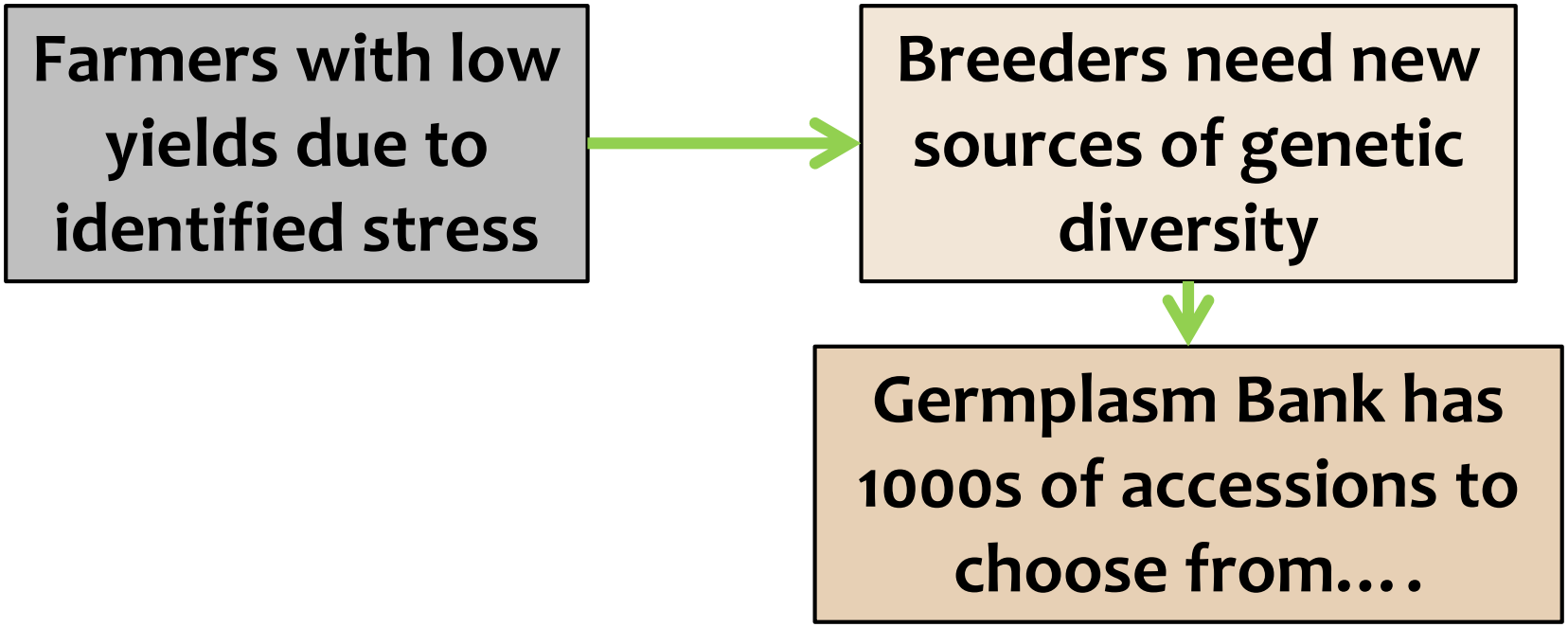
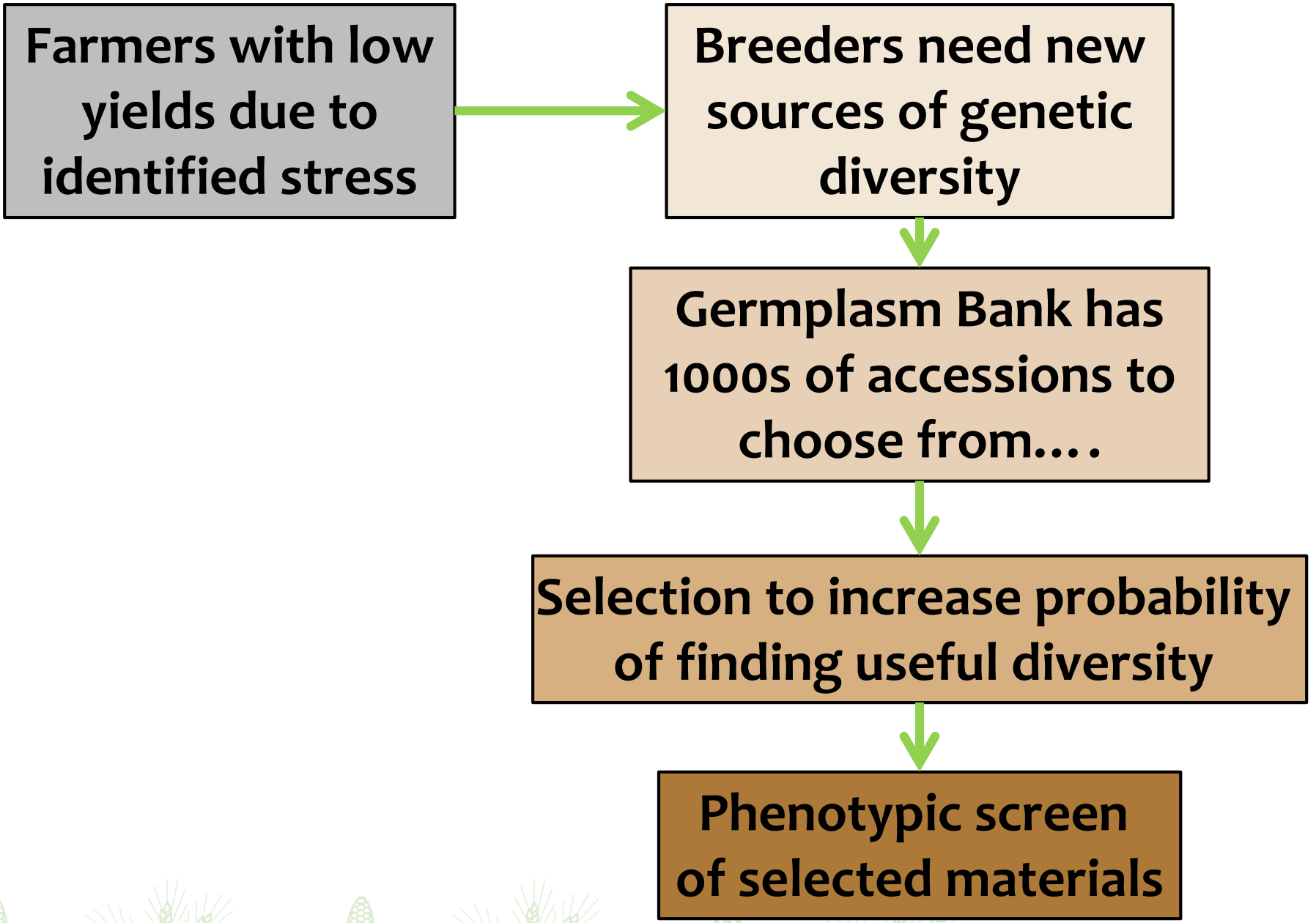
CIMMYT

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….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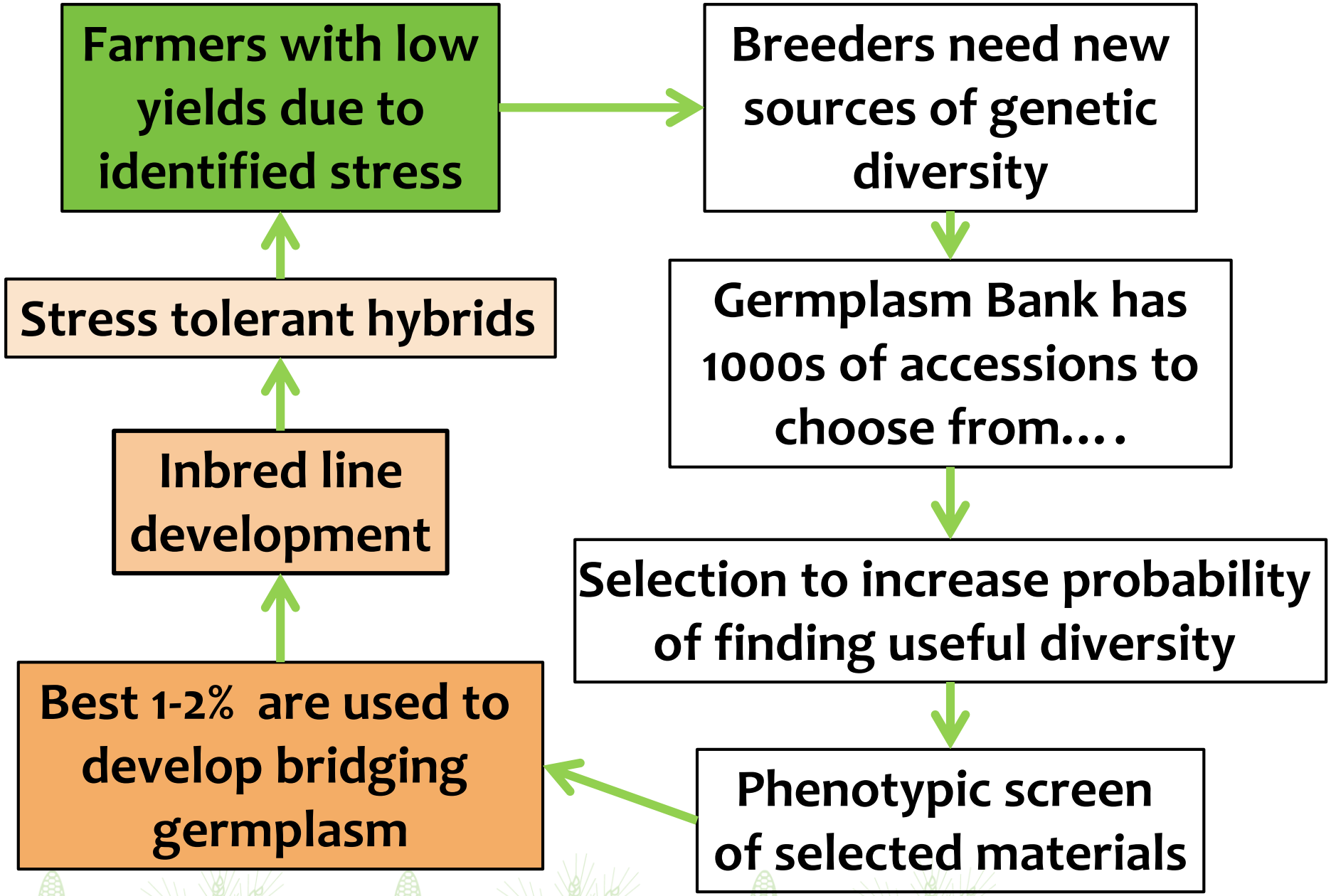
Selection to increase probability of finding useful diversity
Phenotypic screen of selected materials

CIMMYT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Selection to increase probability of finding useful diversity
Phenotypic screen of selected materials
Best 1-2% are used to develop bridging germplasm
Inbred line development
Stress tolerant hybrids

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, Monica Mezzalama & Marcela C. Andrade (CIMMYT-GRP: SeeD, GHU)

Selection Process:

1. Geographic and Phenotypic Criteria

MLN

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
Comiteco	2	34
Vandeño	1	34
Zapalote Chico	1	34
Chandelle	7	30
Tuson	9	28
Bolita	1	23
Cubano Amarillo	6	21
Dzit-Bacal	2	20
Carioco	2	19
Costeño Cristalino	12	19

- Started with Peru where MCMV was 1st described in the coastal lowlands.
- Then other coastal areas of northern S. America.
  - Ecuador, Colombia, Venezuela.
- Then from areas known to have high virus pressure and virus resistant landraces.
  - Southern Mexico, Guatemala, the Caribbean Islands.
- Selected materials between 0 & 1500 meters in altitude.
- Within each region, tried to sample as many maize races as possible.

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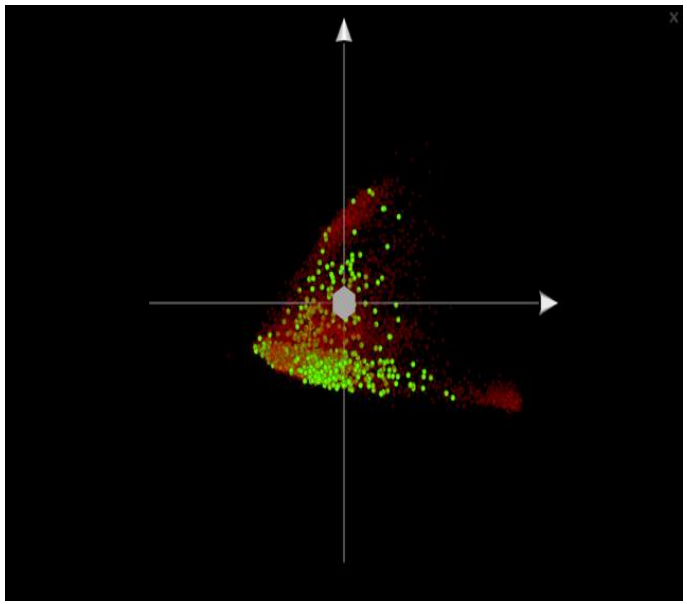
Selection Process:
2. Genetic Diversity Criteria

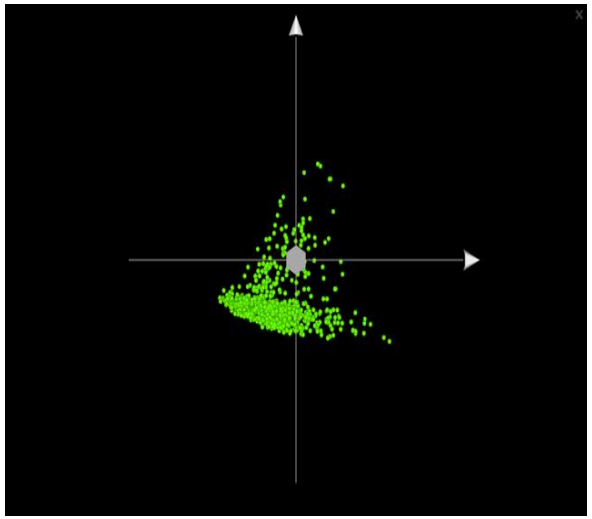
MLN

Top Countries or Region	# of Access.
Mexico	435
Guatamala	150
Venezuela	117
Caribbean	115
Peru	108
Ecuador	36
Columbia	29



Red dots = unselected from 20 K accessions in data set

Green dots = final selection of 1000 accessions



Used genetic distance data generated from the Maize Molecular Atlas to ensure a broad level of genetic diversity in the 1000 selected.

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Phenotypic screen

MLN

Disease Rating	Description	Claim
1	NO VISIBLE MCMV SYMPTOMS [ELISA –ve]	Resistant
2	NO DISTINCT MCMV SYMPTOMS [ELISA +ve]	Resistant
3	FINE CHLOROTIC STRIPES ON LOWER LEAVES	Resistant
4	FINE CHLOROTIC STRIPES ON LOWER AND UPPER EMERGING LEAVES	Tolerant
5	CHLOROSIS STRIPES AND MILD MOTTLING ON PLANT	Tolerant
6	CHLOROSIS STRIPES AND 50% MOTTLING ON PLANT, NECROTIC STRIPES ALSO SEEN	Tolerant
7	EXCESSIVE CHLOROTIC MOTTLING ON WHOLE PLANT, NECROTIC STRPES	Susceptible
8	EXCESSIVE CHLOROTIC MOTTLING ON WHOLE PLANT PLUS SHORTENED INTERNODES, SEVERE NECROTIC STRIPES, SOME TIME MORE MARGINAL LEAF NECROSIS	Susceptible
9	DEAD PLANT	Susceptible

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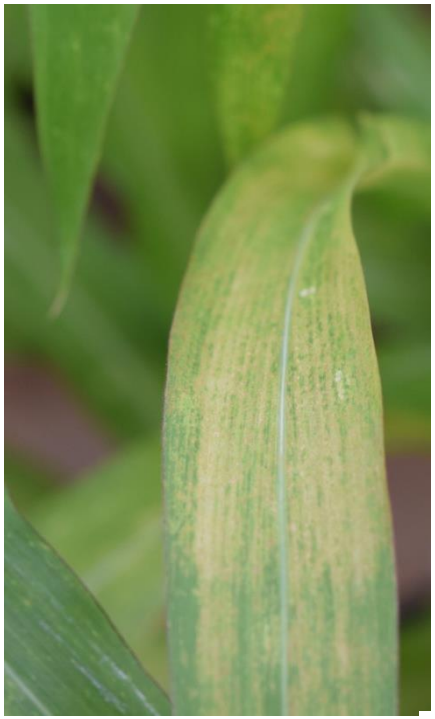
Phenotypic screen

MLN

Mottling

Chlorotic stripes



Inter-veinal necrosis / severe chlorosis

Chlorotic spots to chlorotic stripes

Phenotypic screen

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 six months of screening, went from 1000 accessions down to 20 with putative tolerance to MCMV, SCMV or both viruses.

Breeding and Evaluations – The Long and Winding Road…..

MLN

- F1 crosses between the best 20 accessions and elite CML lines were made & advanced to F2, then F3.
- In 2016/2017, 715 F3s evaluated in the greenhouse for MCMV resistance and 90 were selected as tolerant.
- In 2017/18, 250 F4 families derived from tolerant F3 lines under evaluation for MCMV resistance at Naivasha, Kenya
- In 2019, expect to deliver F4 lines with novel alleles for MCMV tolerance

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MLN tolerant accessions => acceptable product??

Linkage drag

The take-home messages….

- The use of the genetic resources found in international germplasm banks in crop improvement is about to accelerate very quickly
- This can only happen if these resources remain **accessible to everyone** in the global community
- It takes a "village" of many different types of researchers to do this work
- There is ample opportunity for all kinds of talents and interests!

Buena Milpa Project:
New Seed Drying Technologies For All Germplasm Banks
(especially the smallest!)

Guatemala
November 2015

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Farmers' Methods to Store Grain & Seed

In corn cribs ("trojes") or metal silos, in the husks or shelled in sacks

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Community Seed Reserves provide an alternative storage option for seed

Local Agrobiodiversity Collection

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Jan-Feb
HARVEST
Year 1

Grain for consumption/sale

Seed for planting next cycle

March
PLANT
Year 2

Repeat….

Community Seed Reserve Private Accounts

CIMMYT

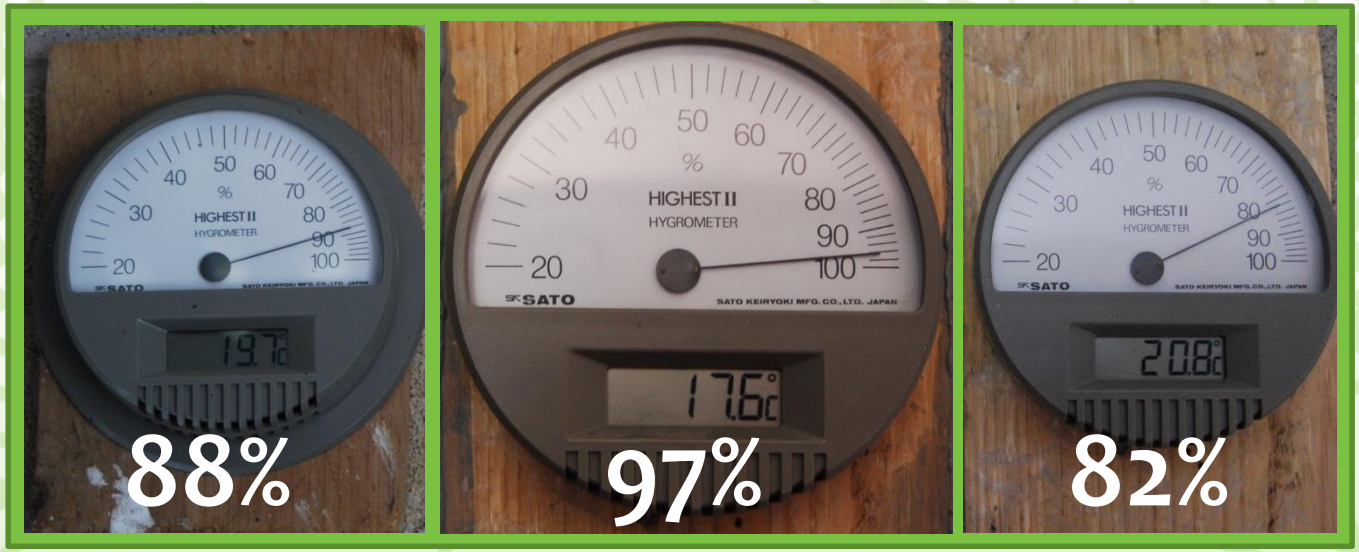
Community Seed Reserves provide other important services

Improved Seed

Emergency Grain in silo

PROBLEM:

Inside the Community Seed Reserves, the humidity is very high.



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PROBLEM:

Inside the Community Seed Reserves, the humidity is very high.

Economical Solution:

Lower the humidity inside the seed containers,

NOT in the whole building.

CIMMYT

Opening the doors to India's first Low-energy genebank!

"…uses an **innovative technique based on desiccants** to dry vegetable seeds for storage – a technique that **requires very little power** to operate."

http://www.bioversityinternational.org/news/detail/opening-the-doors-to-indias-first-low-energy-genebank/

CIMMYT

Drying Beads® -- “Cuentas Secadoras”

Dry seeds are completely resistant to insect Infestations.

The concept is: “Make the seeds DRY, and keep them DRY.”

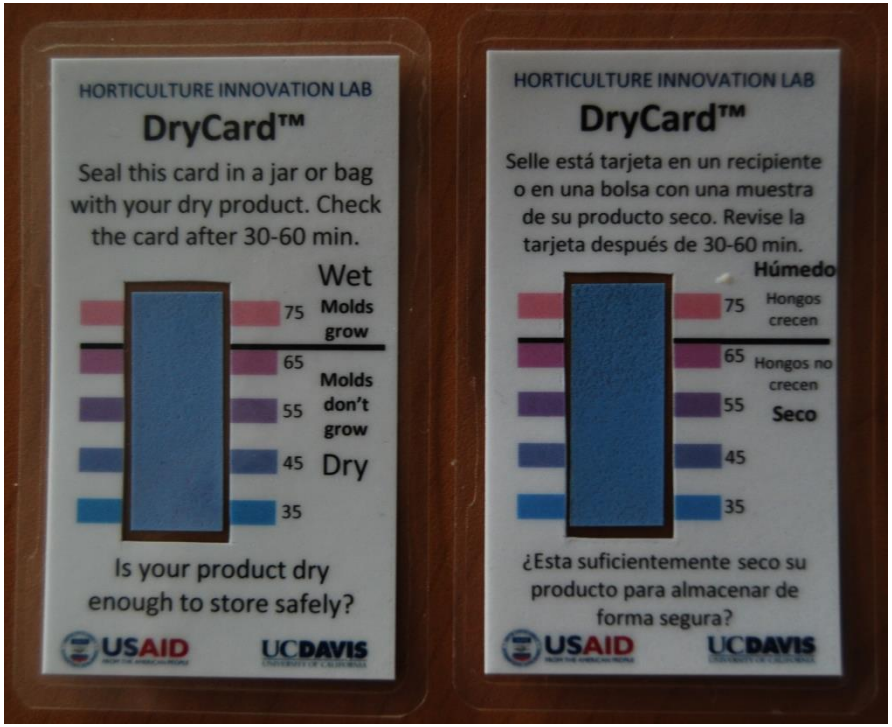
http://www.dryingbeads.org/

CIMMYT®

Pedro Bello (UC-Davis) shows the Buena Milpa team and Local Ag Technicians how Drying Beads work

CIMMYT

We need an easy, inexpensive way to monitor humidity… DryCards™!!



Earth Empower is the licensed source for DryCards in Mexico and Guatemala

English and Spanish versions

Developed at UC-Davis

CIMMYT

DryCard Testing in the Genebank

15-16% grain humidity

13%

7-8 % grain humidity

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September 2017: Shipment arrives, The Dry Chain chapter begins….

CIMMYT

September 2017: Shipment arrives, The Dry Chain chapter begins….

SÉCALO y mantenlo SECO

CIMMYT

RESCUING the JALA Community Seed Bank

13 coffee cans of Jala landrace seed, donated by farmers to start a community seed bank

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DryCards tell the story….

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Jala Seed Drying Experiment Results

Starting Grain Moisture = 14.8 – 16.8 %

Mean = 16.15 %

22 days in Dry Drum

6 kg beads +20 kg seeds

Final Grain Moisture = 10.7 – 11.0

Mean = 10.8 %

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Future Community Seed Bank of JALA

9 May 2018

5 September 2018

RESCUED!

CIMMYT

The Dry Chain in the CIMMYT Germplasm Bank

1. Drying Beads

- Small quantities of seed
- Small numbers of accessions (in early or late harvested materials)
- To accelerate the final stage of drying
- To match moisture levels in different batches of the same accession
- Conversion of heat-driven dryer to drybeads

The Dry Chain in the CIMMYT Germplasm Bank
2. DryCards

- Newly regenerated accessions
- Randomly throughout the vault
- To monitor moisture levels in flasks that are outside the vault for distributions
- In the oldest accessions

Jan-Feb
HARVEST
Year 1

Grain for consumption/sale

Seed for planting next cycle

March
PLANT
Year 2

Repeat….

Community Seed Reserve Private Accounts

CIMMYT

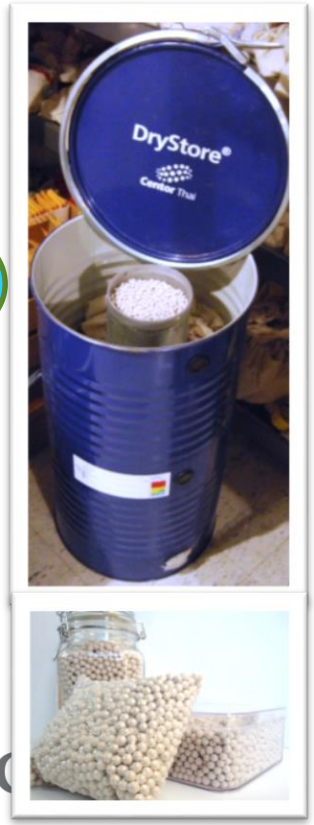
DRY CHAINing in Community Seed Reserves

Jan-Feb HARVEST

Take new seed to store in CSR

DryCard Test

OR



DRY CHAINing in Community Seed Reserves

Jan-Feb
HARVEST

Take new seed
to store in CSR

DryCard Test

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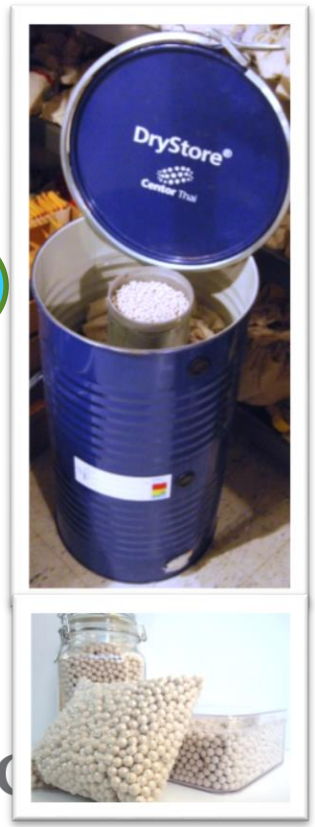

MONITORING

CHECK SEED
VIABILITY
in SAND BENCH

March (Yr 2)
PLANT

We have the seed, the expertise, and the mandate…

CROP TRUST
SECURING OUR FOOD, FOREVER

CGIAR
Genebank Platform

CIMMYT

…in order to help farmers like these

CIMMYT

Muito obrigado!