From collection to cultivation: exploring and expanding the use of native maize diversity in breeding

Sarah Hearne – CIMMYT



The CIMMYT Germplasm Bank

CIMMYT Wheat Germplasm Bank holds accessions from



~ 150,000 accessions

CIMMYT Maize Germplasm Bank holds accessions from



~ 28,000 accessions

Why bother with diversity?







Challenges of Use



Terry Molnar



Challenges of Use

Extreme Diversity: within-plot flowering range of landrace x tester F1s (Willcox y Burgeño).





Challenges of Use

Lack of relevant information



Finding the diamonds in the rough







The Grand Challenge

- Demand for food will increase by 50-60% during the 21st century (FAO 2012)
- Genetic gains in the developing world are around 1% each year (best estimate Fisher, Byerlee & Edmeades, 2012)
- Climate change lowers crop yields by about 5% per degree of warming (Challinor 2014): Eradicates 2-3 out of 10 years of breeding
- 45% of the global area sown to major staples is found in low- and lower-middle income countries, along with 84% of the world's poor
- However, these countries receive just 5% of private sector breeding investment



Seeds of Discovery (SeeD) MasAgr (MasAgro Biodiversidad)





- Initiated September 2011
- Predominantly funded by the Mexican government



Four pillars of work



Genotypic characterization of germplasm banks and public elite germplasm

Phenotyping and Markertrait associations

Pre-breeding

Capacity Development Data Management

A "Sat Nav" for diversity







Molecular characterization

- Genomic characterization using DArTseq SNP and SilicoDArT markers
- Modified protocol- composite samples



Diversity of CIMMYT Maize Germplasm Bank



17353 Landraces with GIS derived data - 15384 presented

Breeder panels





F1 association mapping (FOAM)





Focus on field-based phenotyping

Traits	Experiments	
Abiotic stresses	heat	
	drought	
	low N	
Biotic stresses	tar spot, ear rot, stalk rot, Turcicum, Cercospora, MLN (MCMV & SCMV)	
Grain quality	hardness, starch, oil, amino acids, phenolics	

 Maize: >1.5m data points

Flowering Plant, ear height Stem, root lodging







Flowering and broad adaptation





Inv4m



Inv4m locus 4 - additive effect

Inv4m haplotype clustering

Days to anthesis by cluster



Largest effect on flowering documented to date

Maize: Grain protein content



Total number of markers: 611467





Environmental GWAS & Selection sweep



Realizing promise- pre-breeding

- Development of inbred and semi-inbred germplasm which contains high value exotic alleles in elite backgrounds
- Good agronomic performance is needed in addition to novel genetic variation



"Pre-breeding"







Pre-breeding

- Drought tolerance at flowering
- Heat tolerance (>40° C) at flowering & during grain fill
- Resistance to the MLN Virus Complex
- Resistance to the Tar Spot Disease Complex
- Maize with high-anthocyanin kernel content.

Per-se testing, BC breeding, GS





Drought Tropical Y1 Results: top 10 entries

		DR Yield	WW Yield
Tester	Entry	(BLUP)	(BLUP)
N/A	LPSC7-F64/CML550*	4.92	7.41
CML264/CML311	CML376<2(ARZM12237)-61-1	4.68	6.87
CML264/CML311	CML376<2(COAH21)-3-1	4.67	7.06
CML264/CML311	CML376<2(COAH117)-47-1	4.62	6.83
CML264/CML311	CML376<2(CHIH338)-48-1	4.61	6.95
CML264/CML311	CML376<2(SNLP17)-49-1	4.60	6.91
CML264/CML311	CML376<2(COAH20)-5-1	4.60	7.11
CML264/CML311	CML376<2(SNLP169)-18-1	4.58	6.85
CML264/CML311	CML376<2(CHIH338)-12-1	4.57	6.74
CML264/CML311	CML376<2(NVOL46)-74-1	4.57	6.78
CML264/CML311	CL106951**	4.55	6.97
CML264/CML311	CML376<2(COAH18)-28-1	4.54	6.74
CML264/CML311	CML376	4.24	6.45

* LPSC7-F64 = La Posta Sequia selection; CML550 = elite tropical drought resistant line.

** CML264/CML311//CL106951 = MasAgro hybrid.

4 loc

Assessment of options; simulations



GS in landraces

		Tested Genotypes	
		Y	Ν
Tested Environments	Y	CV2	CV1
	N	CV0	CV00

Plant Height CV1

Plant Height CV2



GS in landraces

		Tested Genotypes	
		Y	N
Tested Environments	Y	CV2	CV1
	N	CV0	CV00

Plant Height CV00

Plant Height CV0



Where next?



Where next?







Modernización Sustentable de la Agricultura Tradicional

SAGARPA SECRETARÍA DE AGRICULTURA, GANADERÍA, DESARROLLO RURAL, PESCA Y ALIMENTACIÓN



Thank you for your interest!



research program on Maize



www.seedsofdiscovery.org