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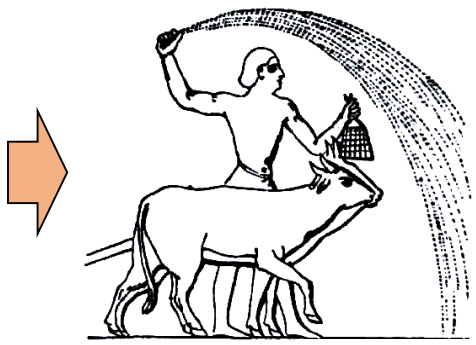
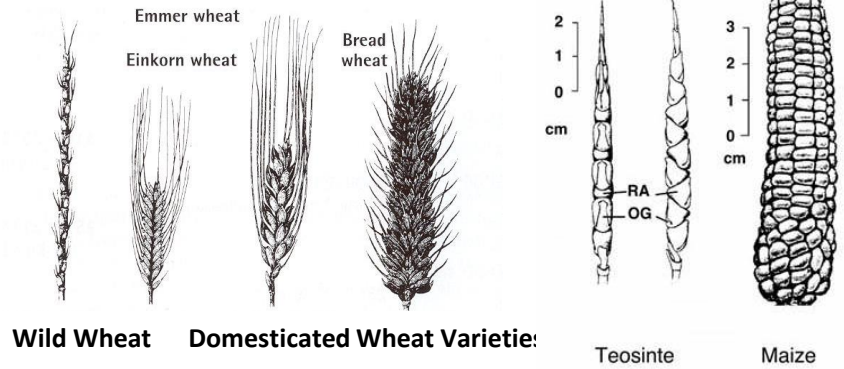
Molecular Breeding & Crop Improvement of Jatropha and Guayule Hybrid Cultivars

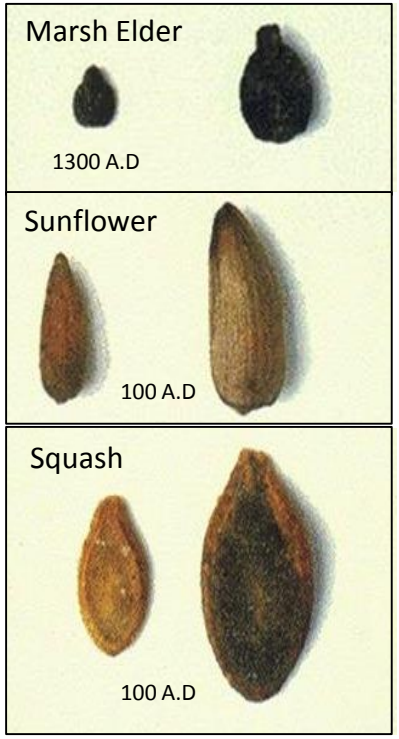
Eric J. Mathur, Chief Science Officer & Senior Vice President

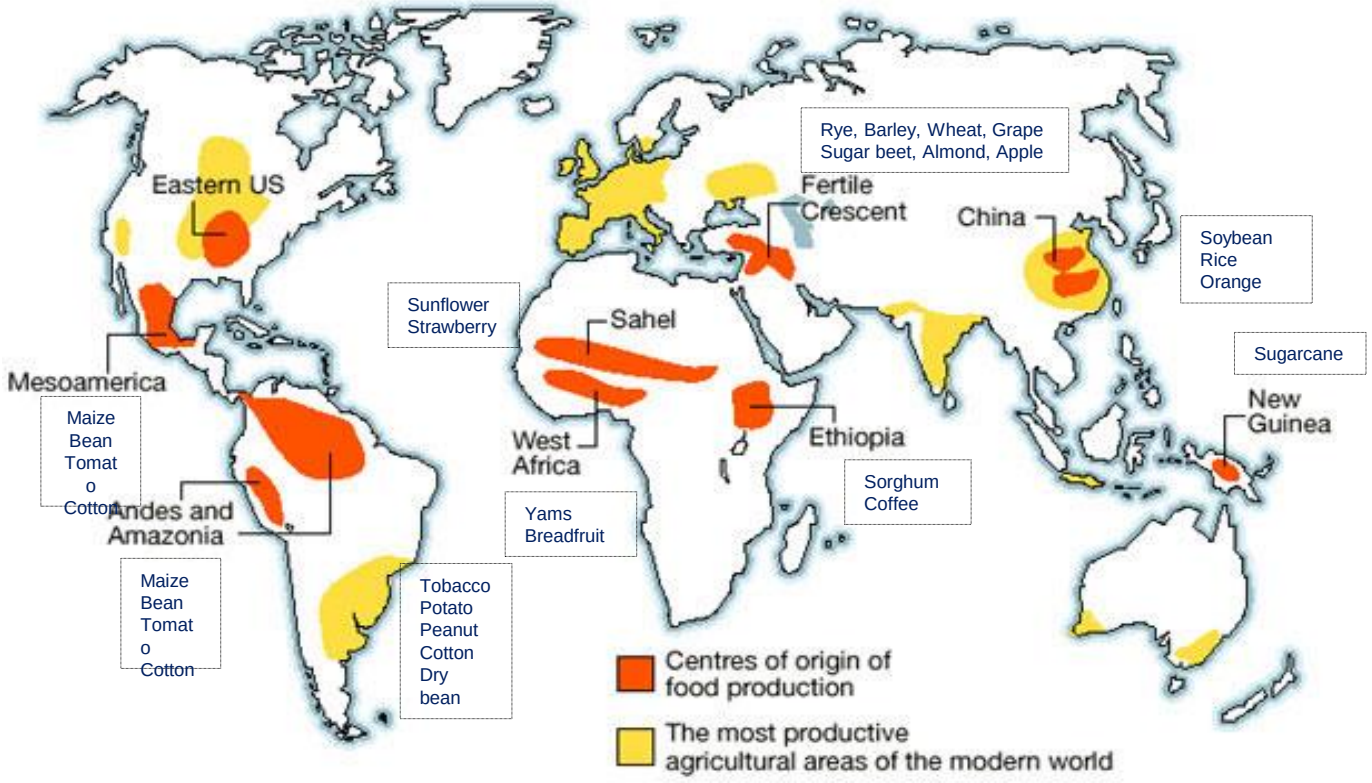
Pacific Rim BIO Summit , San Diego, California. December 8th, 2014

Plant domestication dates back to 8000 BC









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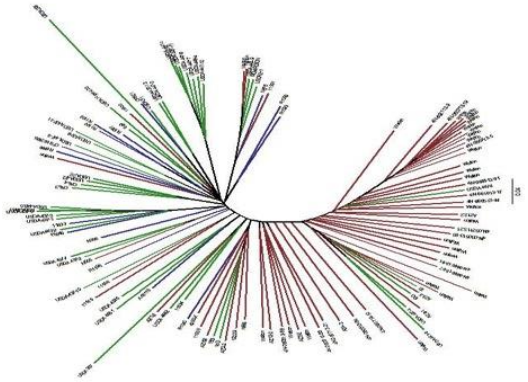
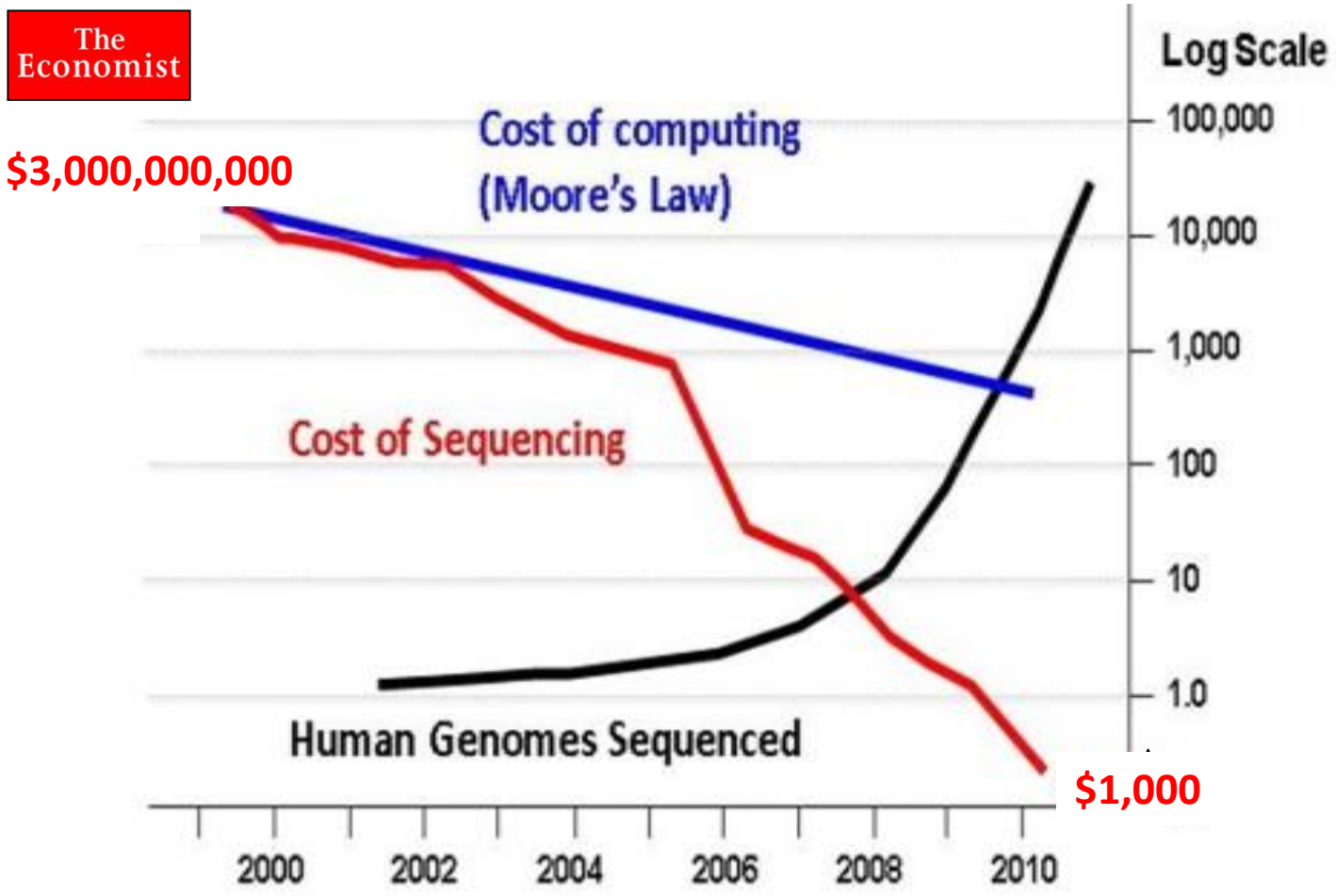


Crop improvement requires diverse germplasm

- Present day crops are improved versions of their wild ancestors
- Diverse germplasm is required for crop domestication
- Jatropha & Guayule landraces lacked genetic diversity

Tomato	100X
Rubber	400X
Maize	25X
Jatropha	50X
Guayule	10X

The era of plant genomics has arrived



The DNA sequencing explosion

Modern Genome Tools

- Physical & genetic maps
- Germplasm phylogeny (GBS)
- Plant re-sequencing
- SNP & gene discovery
- RNA-Seq & proteomics
- Trait: marker association (GWAS)
- Genomic Selection (GS)

Commercial Impact

- Accelerate improvements
- Maximize genetic potential
- Yield preservation
- Consistent productivity
- Uniform plant architecture
- IP protection - DNA barcodes
- Predictive breeding

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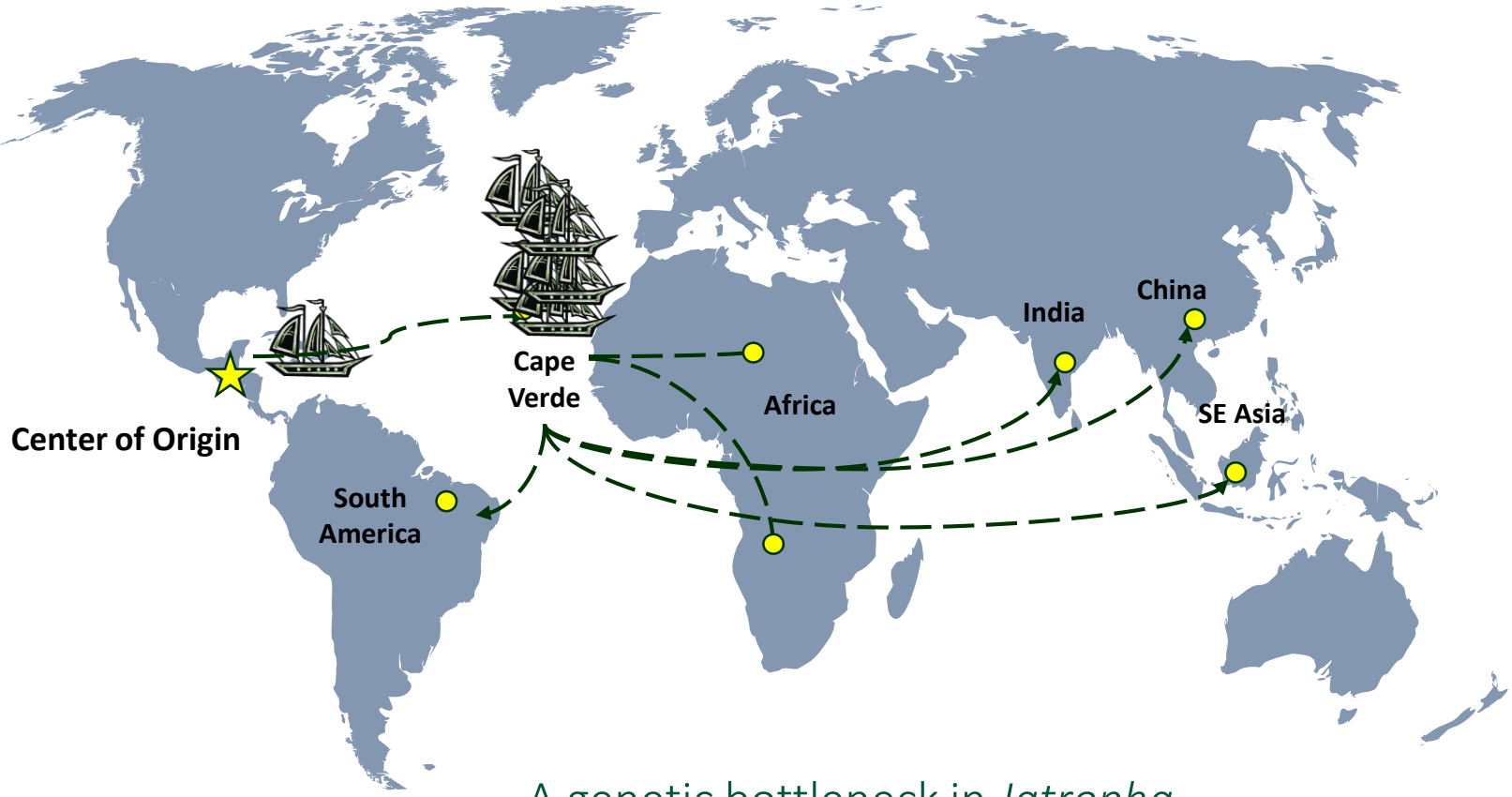
Jatropha produces tri-carpelate fruits with high oilseed content

- Exceptional fatty acid profile
- Excellent oxidative stability
- Good cold flow properties
- High value specialty chemicals
- No competition with food security

Oilseed	Cloudpoint	Stability (hrs@110C)
Canola	-3°C	14.1
Jatropha	3°C	13.1
Soy	1°C	5.3
Palm	13°C	13.4

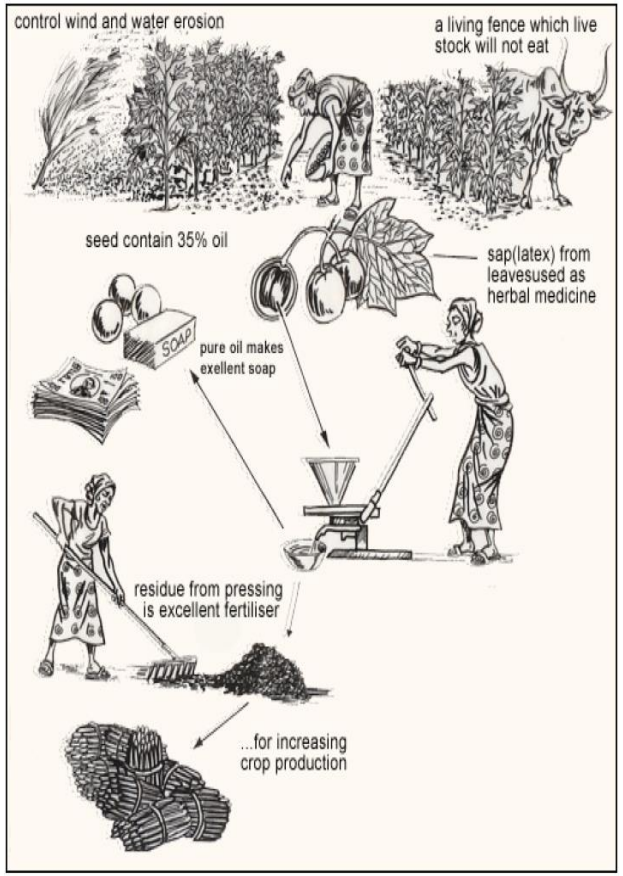
Fatty acids	Jatropha	Palm	Canola
Saturated	19%	49%	6%
Unsaturated	81%	51%	94%
18:1	36%	42%	64%
18:2	45%	9%	19%

Jatropha domestication: case study



A genetic bottleneck in *Jatropha* prevented early domestication

Jatropha oil applications:
biodiesel, jet fuel, specialty oils & chemicals



*Traditional use and local processing of physic nut (*Jatropha curcas *L.).*

soaps

candles

medicinals

living fence

fertilizers

Jatropha has been cultivated for centuries; the Portuguese recognized it's value

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Jatropha germplasm from Central America exhibits high phenotypic diversity

Extreme branching

Apical dominance

Dwarfs

Fungal & rust resistance

Dehiscent Indehiscent

Female only flowers

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DNA barcoding: High throughput digital genotyping

Leaf Punches

Tissue Lysis

HTP DNA Extraction

Liquid Handling

High Resolution Melt

DNA Marker Sequencing

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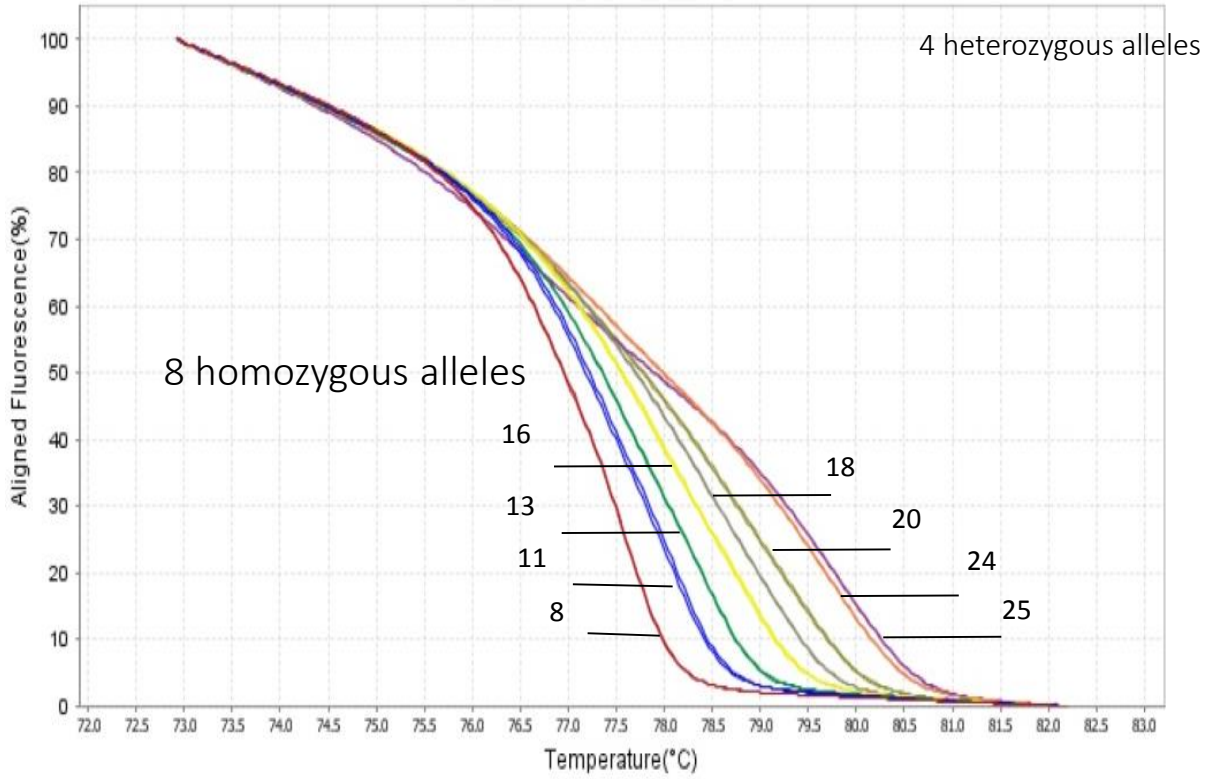
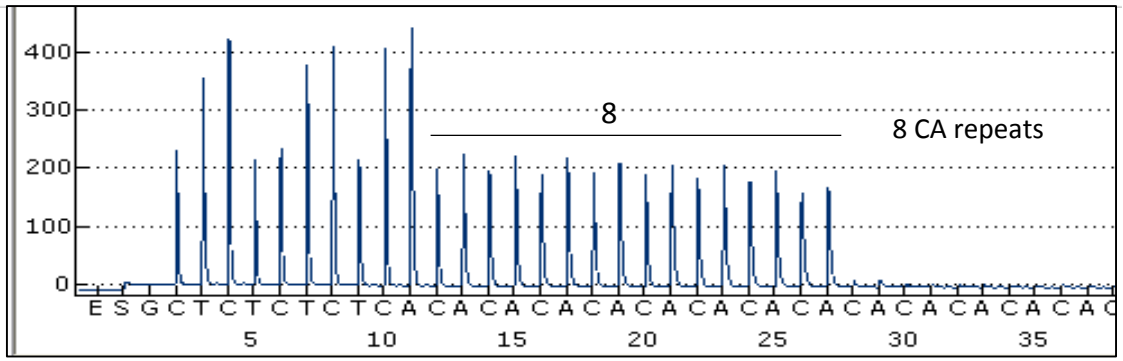
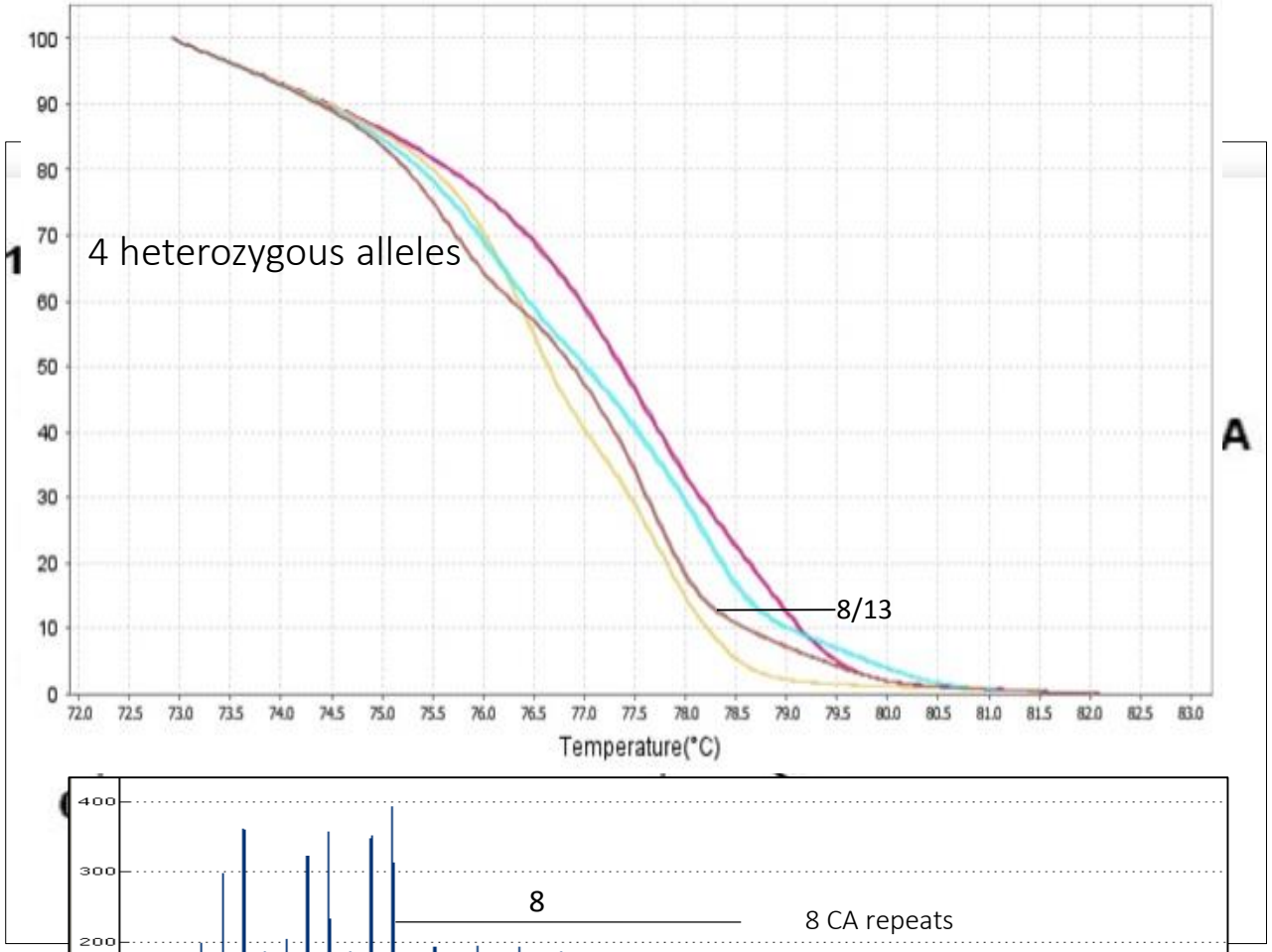
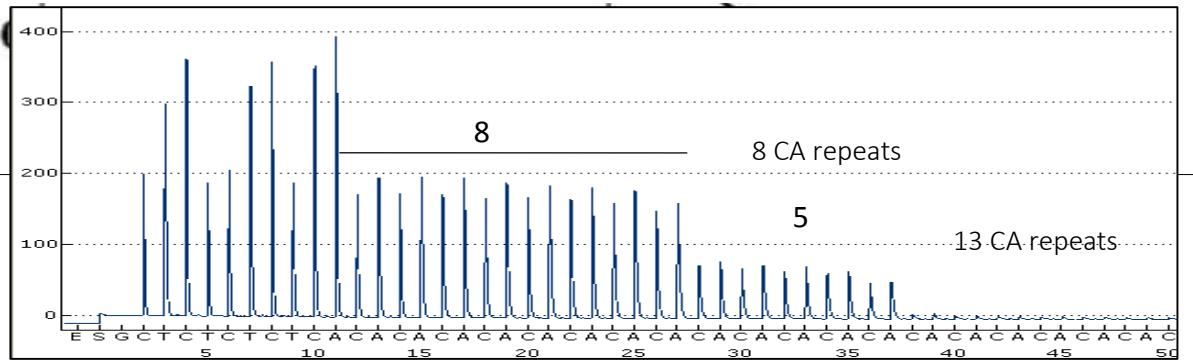
DNA barcoding: HRM genotyping with SSR markers





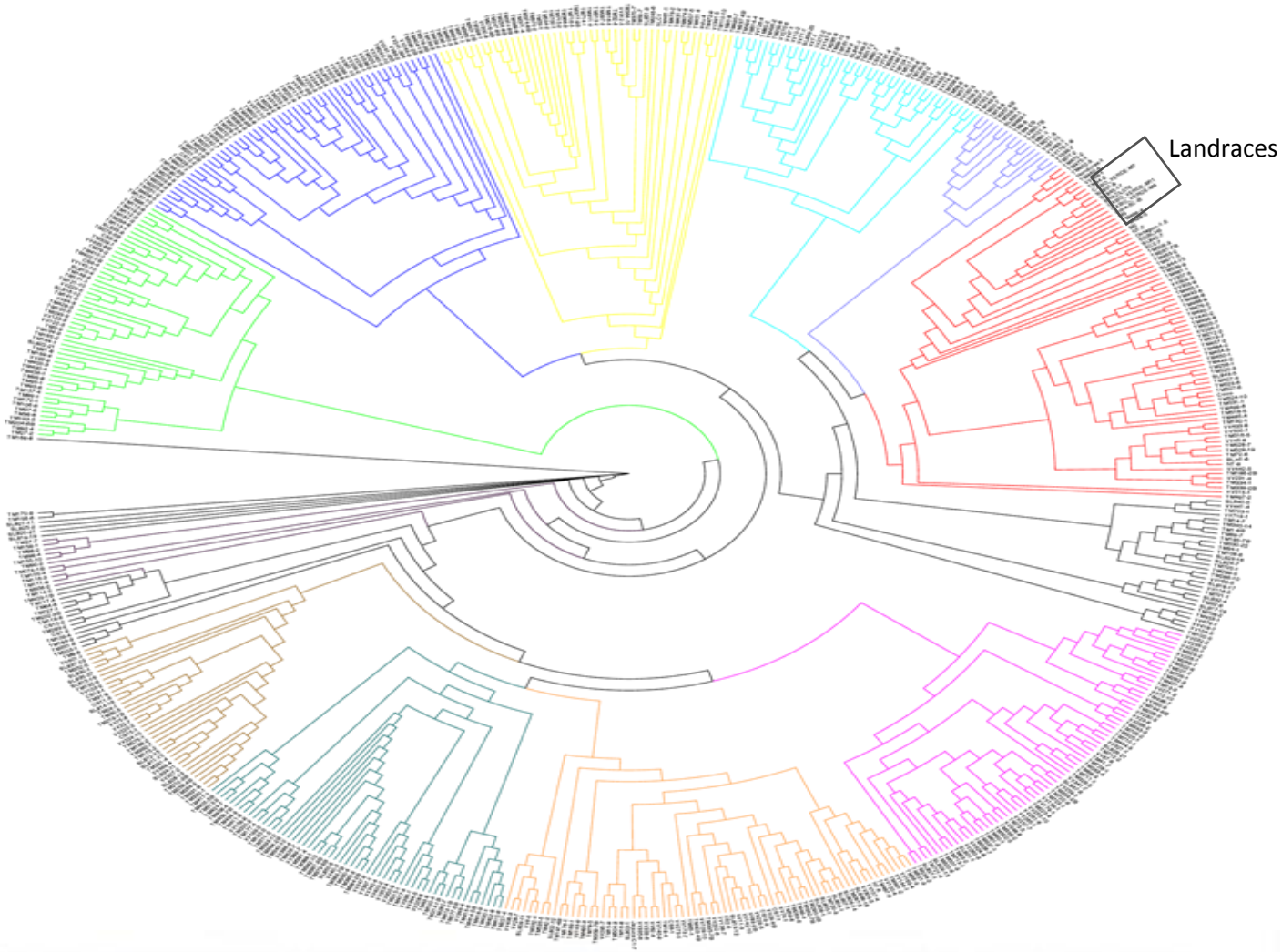


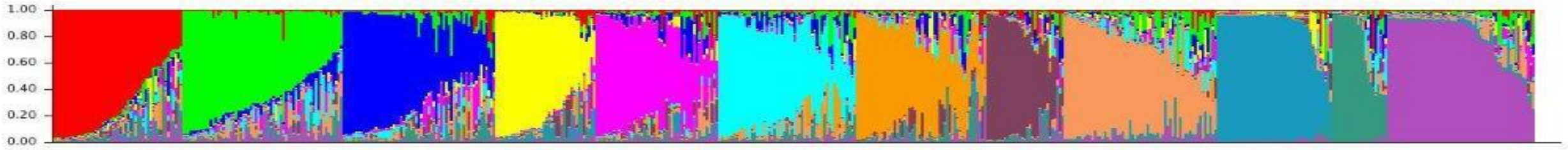


PyroMark Sequencing

Population structure deduced from SSR markers with HRM

- 12 distinct clades
- Identifies best parental lines
- Maximizes hybrid vigor
- Increases plant productivity
- Improves plant health
- Assures yield preservation
- Provides IP protection





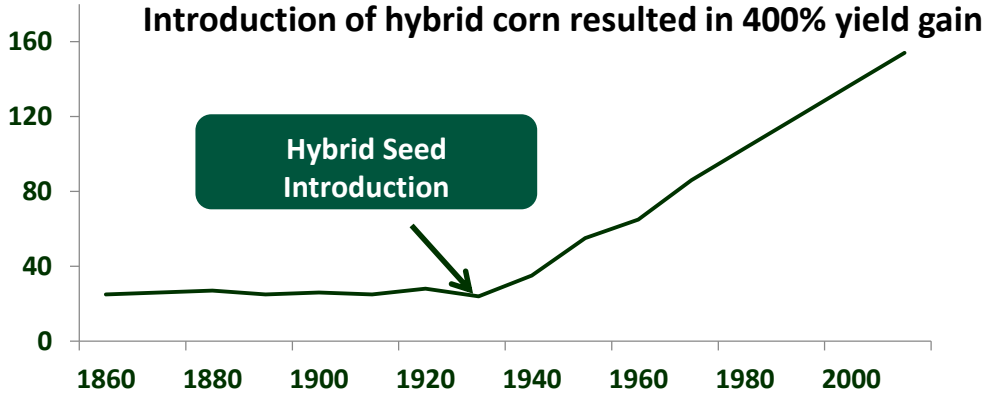
Jatropha hybrid technology improves profitability

Higher Yields
Hybrid vigor; enhanced seed, oil & biomass yield

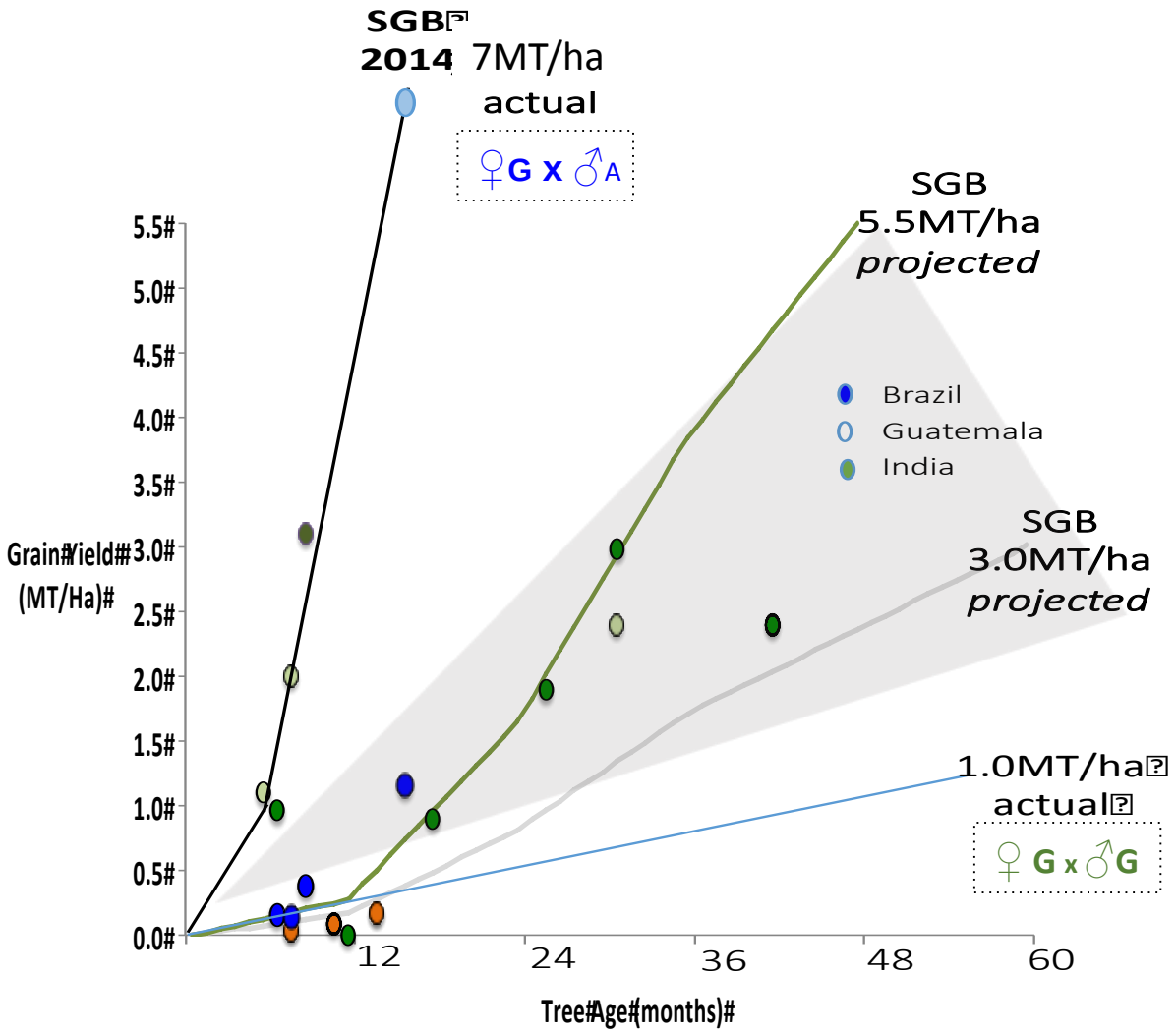
Increased Profitability
Agronomic efficiencies better economics & higher productivity

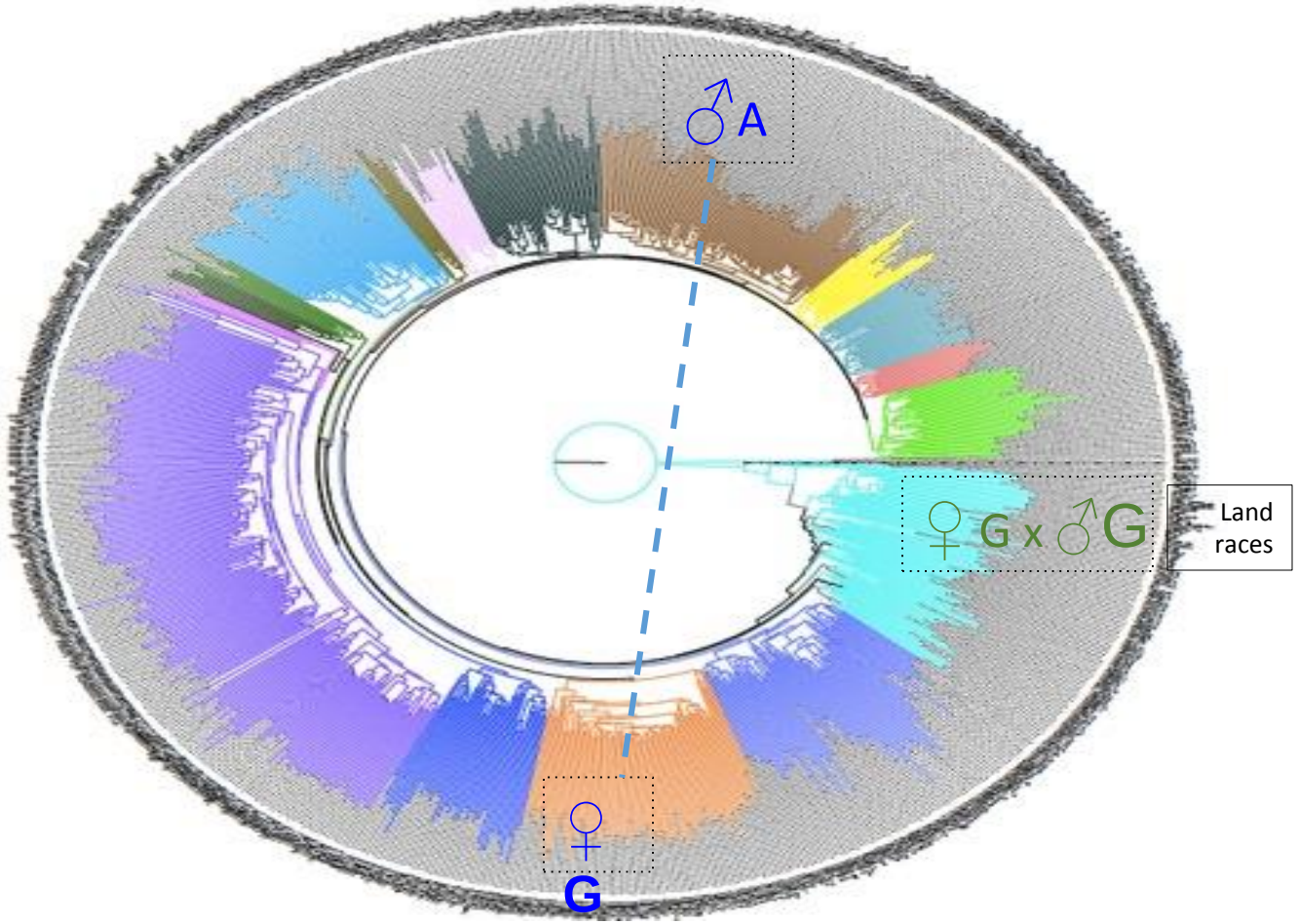
Stress Tolerance
Improved WUE & NUE disease & pest resistance

Preserve Yield Potential
Maintain yield under seasonally adverse conditions



50-fold oilseed yield improvement in Jatropha by maximizing heterosis





800 accession families form
18 heterotic clades with filtered SNPs

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Yulex is a fully integrated business combining patented technology, platform for rapid crop improvement, and product demand across multiple vertical markets

CROP SCIENCE-AG

Proven crop improvement platform

- Molecular Breeding & Agrigenomics
- Hybrid testing & development
- Agronomic & Crop production research
- Seed multiplication & processing
- Sustainable commercial production

BIOPROCESSING

Patented extraction technologies

- Clean bioprocessing
- GEN I Aqueous-based extraction
  - Latex emulsion
- GEN II Solvent-based extraction
  - Biorubber, Resins, Bagasse

MATERIALS SCIENCE

Value creation and market pull

- Application development
- Material enhancement
- Co-branded products
- Yulex Brand for high-value markets

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Yulex emulsion & solid rubber applications

Yulex provides a safer, natural rubber for latex-allergy sensitive individuals

Mattresses

Condoms

Action Sports

Yoga Mats

Medical Tubing

Medical Gloves

Footwear

Gasketing

Balloon Catheter

Dental Dams

Tires and Auto Parts

Children’s Toys

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Marginal genetic improvement over 60 years of breeding

- Narrow germplasm base
- Perennial crop
- High rubber yields require 18 to 24 months
- Multi-year trialing to evaluate and realize yields
- Landraces lack uniformity
- Complicated genetics

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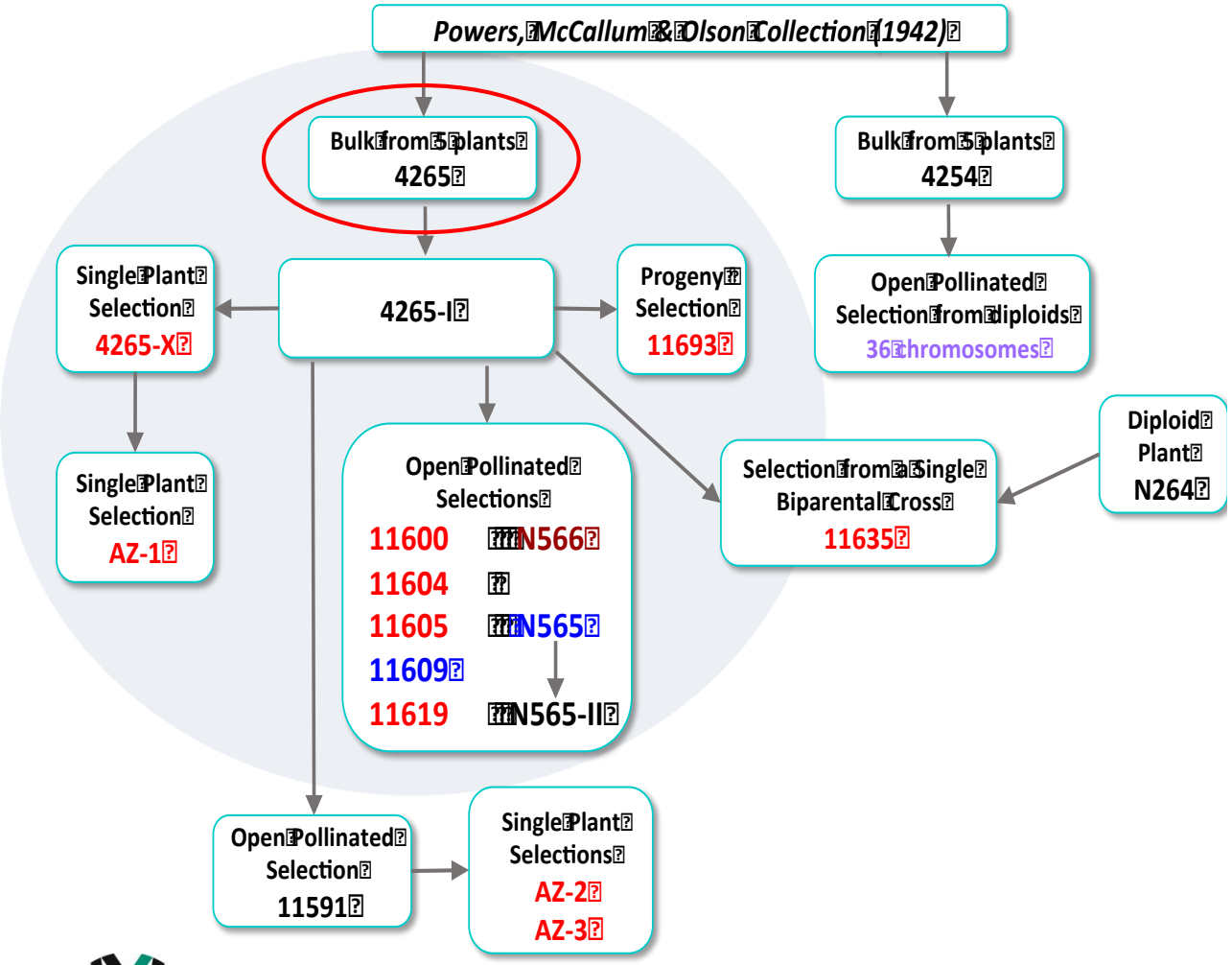
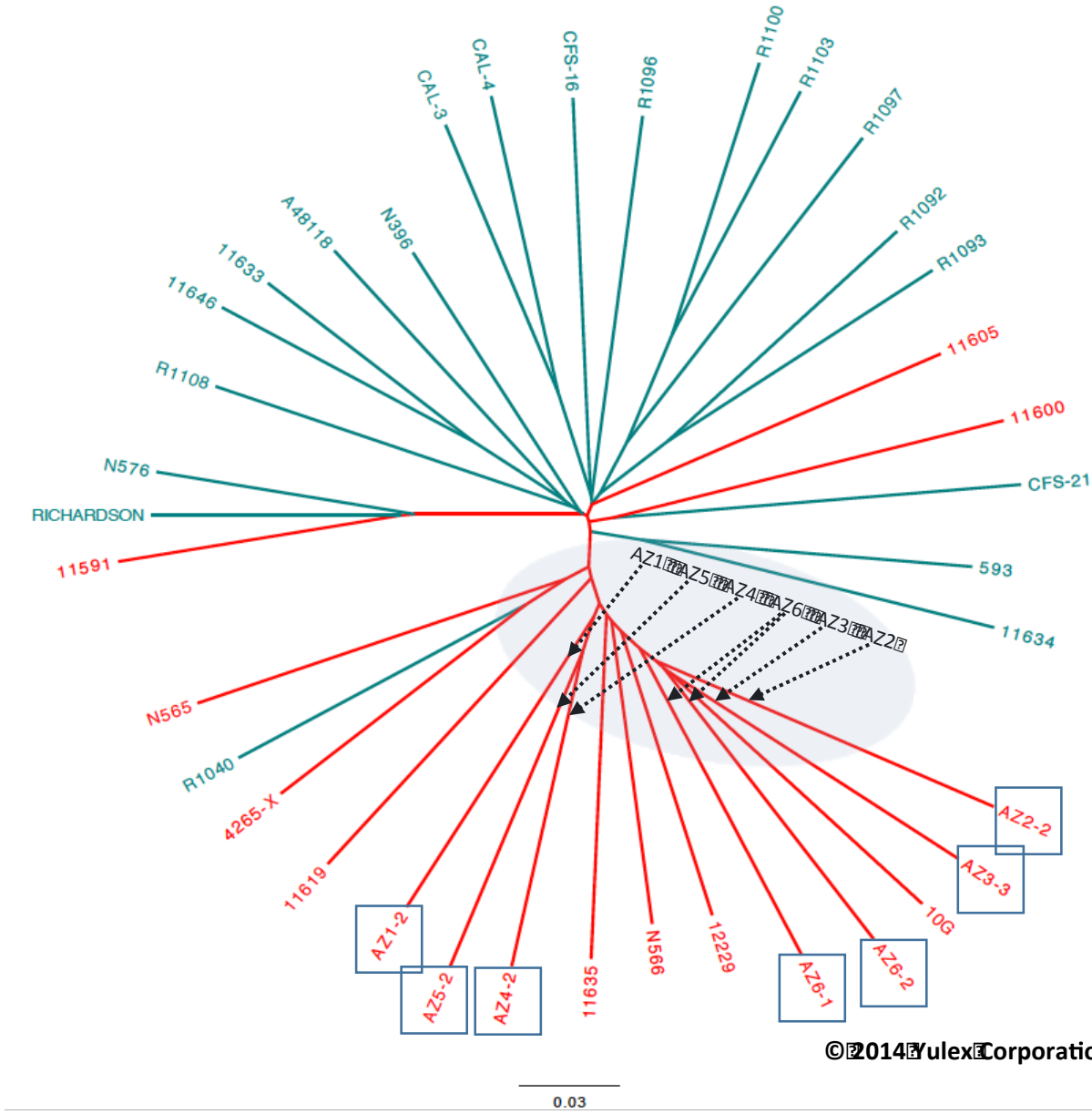
Guayule bottleneck: AZ lineage arose from only *5 bulked plants*





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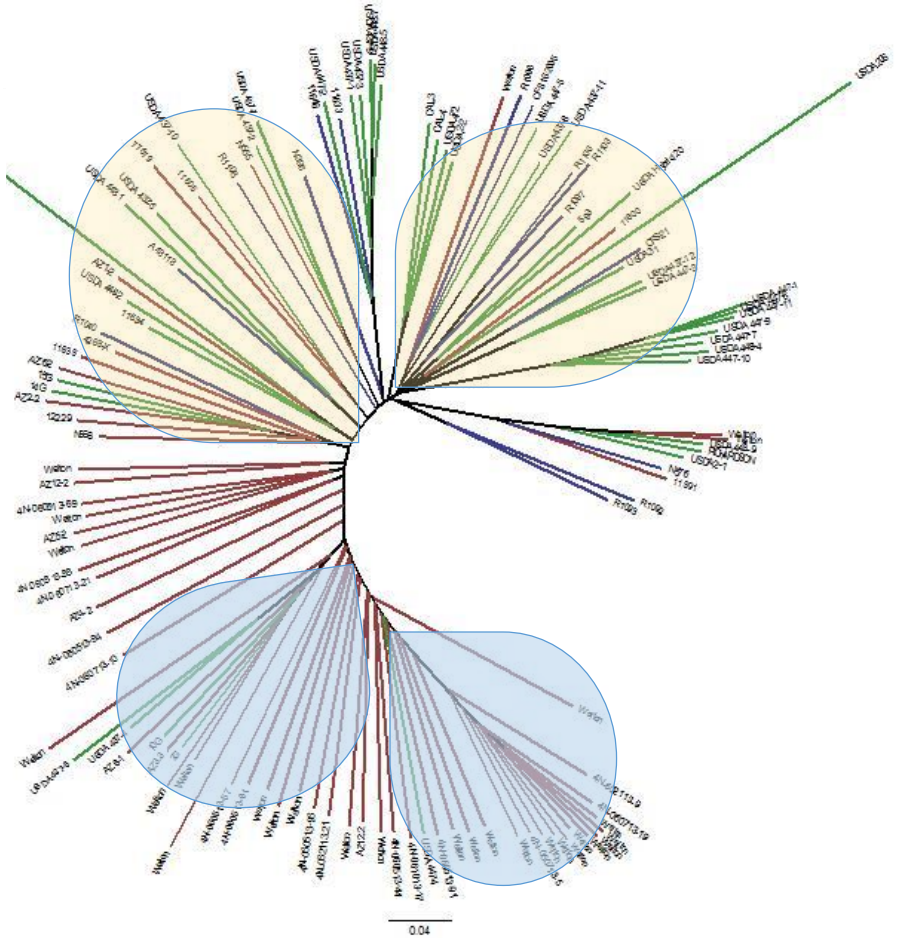
Germplasm diversity exists at the center of origin of *Parthenium argentatum*

A severe genetic bottleneck exists in commercial Guayule germplasm

Guayule center of origin is in Northern Mexico



Selected wild germplasm is highly divergent

Cultivated germplasm is limited in diversity

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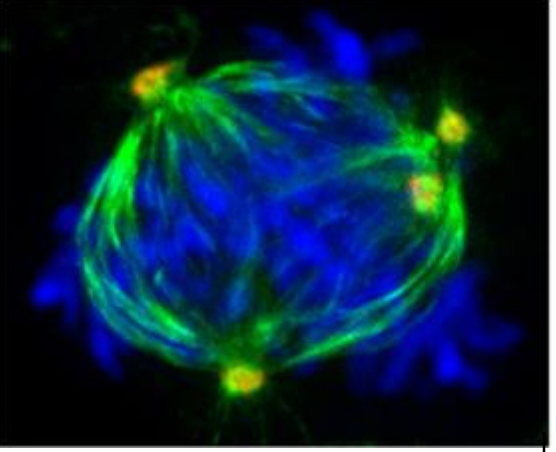
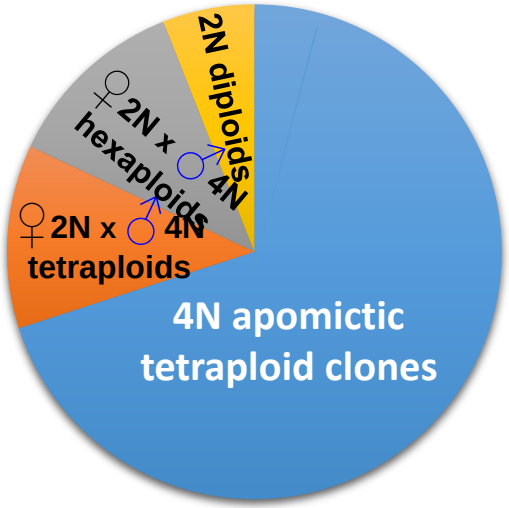


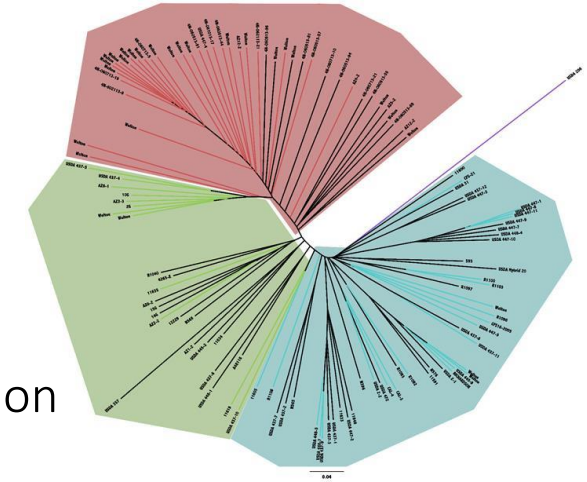
Yulex harnessed guayule genetics to produce pure-line hybrids

- **Traditional breeding methods have been flawed**
  - low trait heritability
  - variability in germplasm
  - 30% genetic dilution with each cycle
  - apomixis restricts genetic gain
  - ploidy & aneuploidy complicate breeding



- **Yulex leveraged facultative apomixis to produce true hybrids**
  - Hybrids are uniform plants with consistent productivity
  - Hybrids can produce clonal progeny
  - Molecular breeding tools maximize hybrid yield & vigor

- **Guayule hybrids represent disruptive technology**
  - 15-fold improvement in rubber yield uniformity
  - IP portfolio on hybrid creation, selection & seed multiplication



Four distinct clades

0.2% rubber content difference between YG50-F15 hybrid plants*

Hybrid Plant Number	Triplicate Extractions	Average % Total Rubber
F15- 9	4.1	4.3
	4.4	
	4.4	
F15-11	4.6	4.5
	4.6	
	4.5	
F15-12	4.2	4.5
	5.1	
	4.3	

*1 yr old plants

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Yulex Guayule hybrids demonstrate high yield performance

Three factors driving higher yield potential of Guayule:

1) Plant rubber content

2) Plant Weight

3) Total Biomass

Genetic yield potential for 2014 Top Yulex hybrids

Yulex Hybrids	Plant Rubber Content (%)	Total Rubber/plant (g)	Total Biomass* (MT/Ha)
Top Performer	**9.5**	**52.5**	**54.3**
Top 10	8.4	30.0	49.1
AZ-6 Check	6.0	18.5	24.8

***Fresh Weight of defoliated 24 month-old plants**

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Acknowledgements

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