Progress in maize variety development and seed systems






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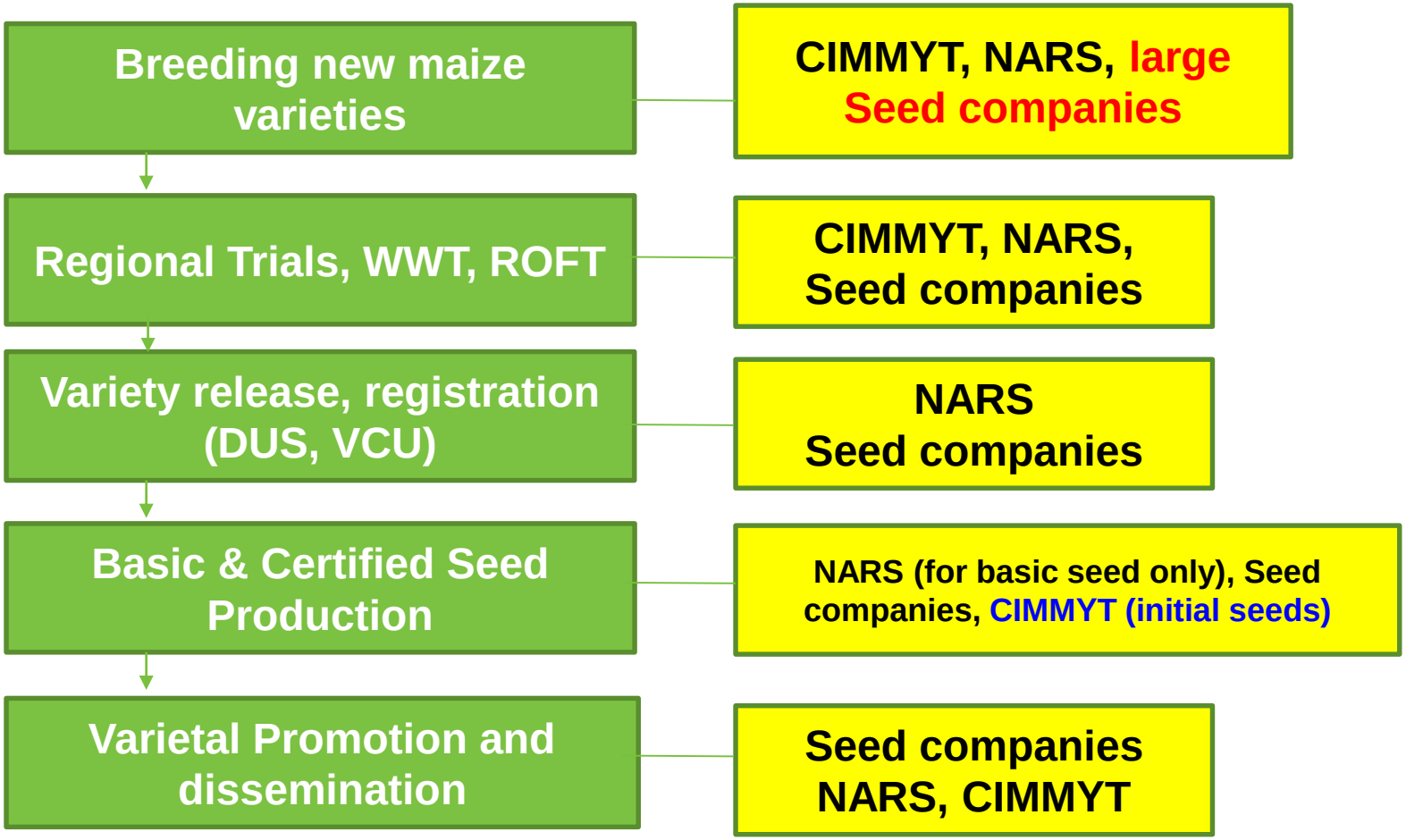
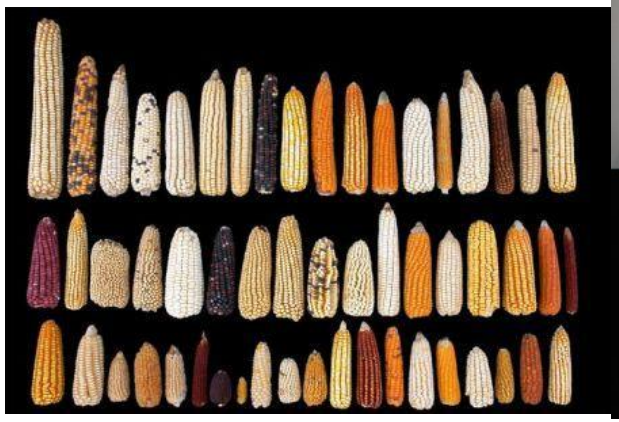
Pathways for maize variety release



CIMMYT Gene bank



- CIMMYT's maize Germplasm Bank contains over 28,000 unique collections of maize seed and related species from 88 countries

- The collections a source of diversity to breed for traits such as heat and drought tolerance, resistance to diseases and pests, and to improve grain yield and grain quality."

Variety development

- Selection from indigenous germplasm
- Hybridization and selection
- Tissue culture
- Mutation breeding
- Marker assisted selection
- Bioinformatics
- Double haploid

Trait prioritization/Trait combinations

Foliar Diseases

MSV, GLS, ET, PLS, PS

Ear Rots/Aflatoxins

Fusarium, Diplodia

High Yield Potential

Local and Introductions
Density response

Striga

Specific in some areas

MLN

New serious challenge

Pests

Field Pests
Storage Pests

Producibility

High yielding females

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Trait prioritization/Trait combination

Drought

Flowering and Grain Filling Drought Stress

Low N

Continues to be a problem

Heat

Heat Stress Alone
Heat Stress Combined with Drought Stress

Low P/Acid Soils

Phosphors Hunger
Acid soils – underestimated problem

Pro A Maize

Potential reduction in Industrial Bio-fortification

QPM

Renewed Demand for QPM

High Zn Maize

Combined with QPM and/or Pro-A

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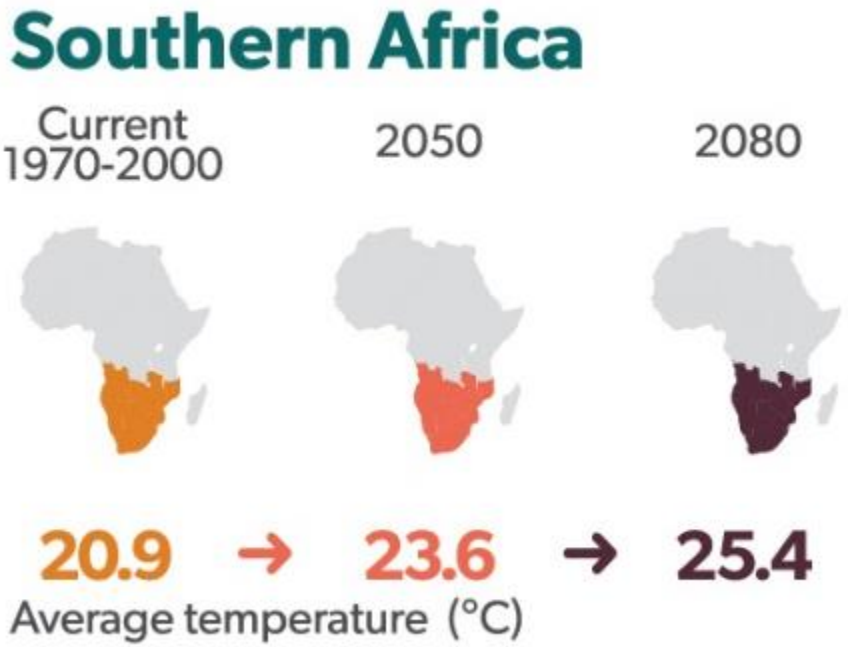
Modelling – influencing the breeding pipeline

2.1˚C increase by 2050
Reduce maize yields by 11% in Zimbabwe

Commercial varieties very sensitive to heat

First heat tolerant varieties commercialized in southern Africa in 2014



Cairns et al. 2012, 2013a and b, Magorokosho et al. in preparation

Modelling – influencing the breeding pipeline

CIMMYT varieties yielded almost double the most popular commercial variety during the El Niño season on 2015/16

(1.5 Mg ha^{-1} compared to 2.9 Mg ha^{-1})

Setimela et al. 2017b

Climate smart, nutritious maize

Borlaug Fellowship

CIMMYT & Cornell (Christine Diepenbrock and Prof Mike Gore)

Genetic stability of pro-vitamin under heat stress

Effects of heat stress on pro-vitamin A concentration

Accelerating variety replacement

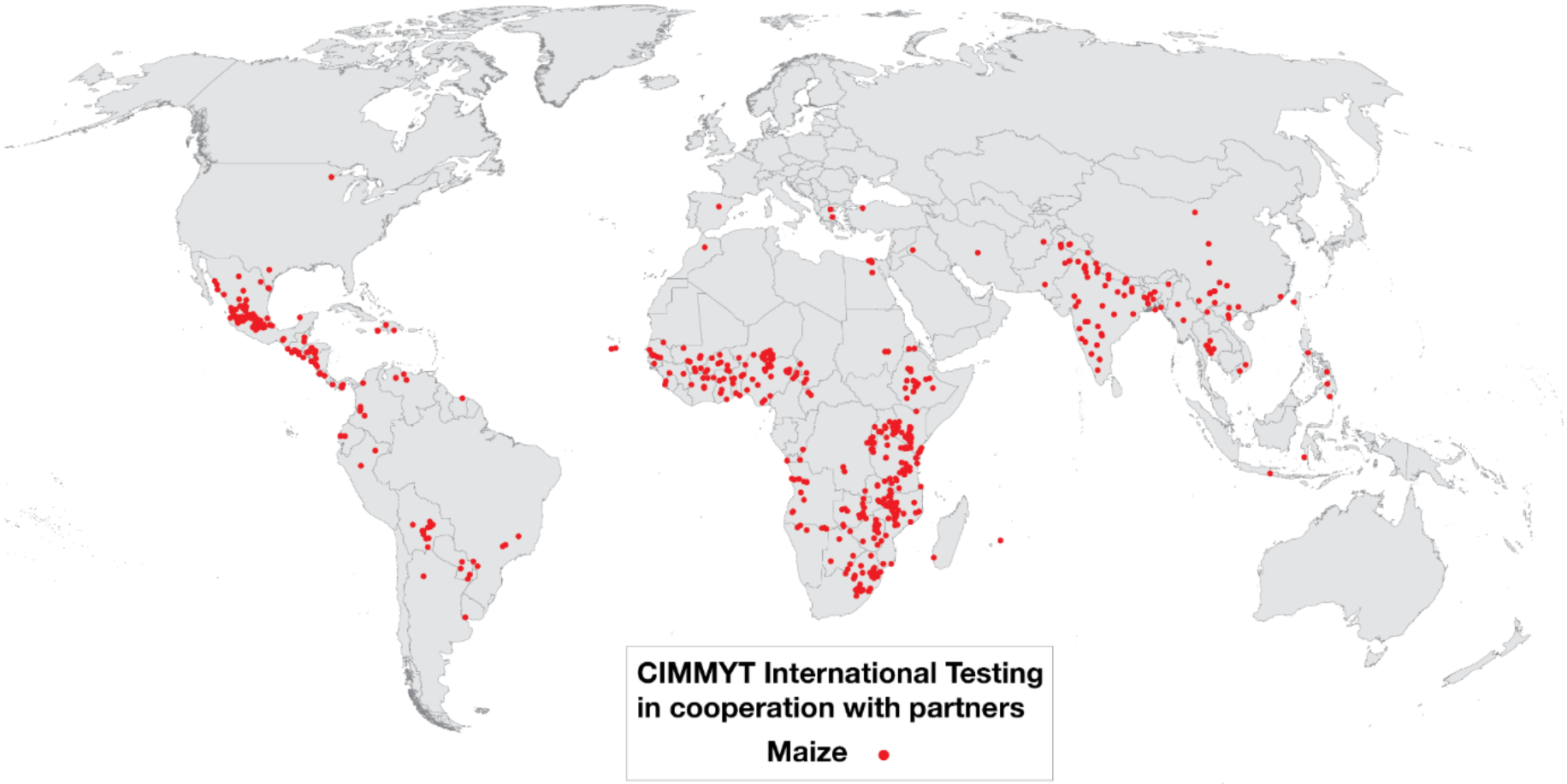
- **Stage III Trials, Across Breeder combinations, Regional Trials**
- **Line finishing, Quality control**
- **Product Profiles**

- **White hybrids (SC, 3-way, Double-cross, OPV)**
- **Yield improvement compared to the best commercial checks:**
  - Managed drought 45 kg/ha/year
  - Low N 45 kg/ha/year
  - Optimal 110 kg/ha/year
  - Per se female yield 45 kg/ha/year
  - MLN 250 kg/ha/year
- **General Product Requirements**
  - Maturity : early, intermediate and late
  - Disease resistance: GLS, NLB, MSV and **MLN**
  - Agronomic traits: root lodging, maturity, husk cover
  - Grain Texture : flint to flinty-dent
  - Color

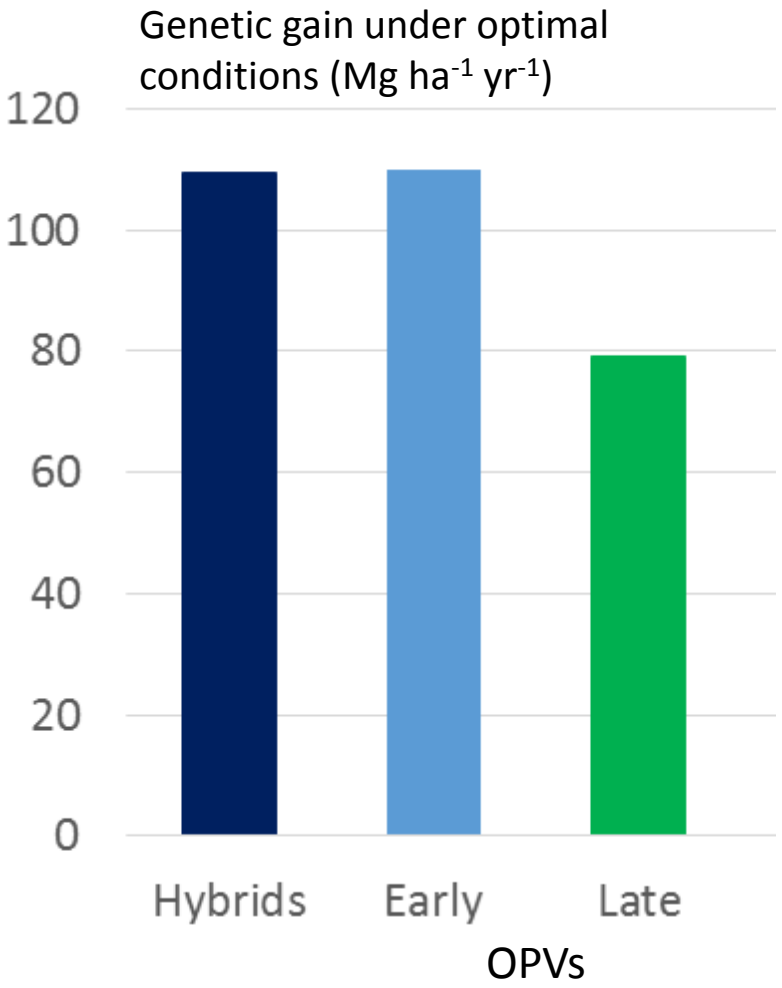
- **Regional Trials (Southern Africa Example)**
  - Early Maturing 50 entries
  - Medium Maturing 70 entries
  - Late Maturing 45 entries
  - OPV 50 entries
  - Parent Trials (Inbreds, OPVs)
  - Nutritious maize trials
  - Approx. 600 sets distributed annually

- **Commercial Checks**
  - SC301, SC403, SC513, SC637, SC727
  - PAN53, PAN7M-81
  - PHB30G19, PHB3253

Regional trial distribution network



Genetic gain in Eastern and Southern Africa



Genetic gain in hybrids

Optimal = 1.4%

Managed & random drought = 0.85%

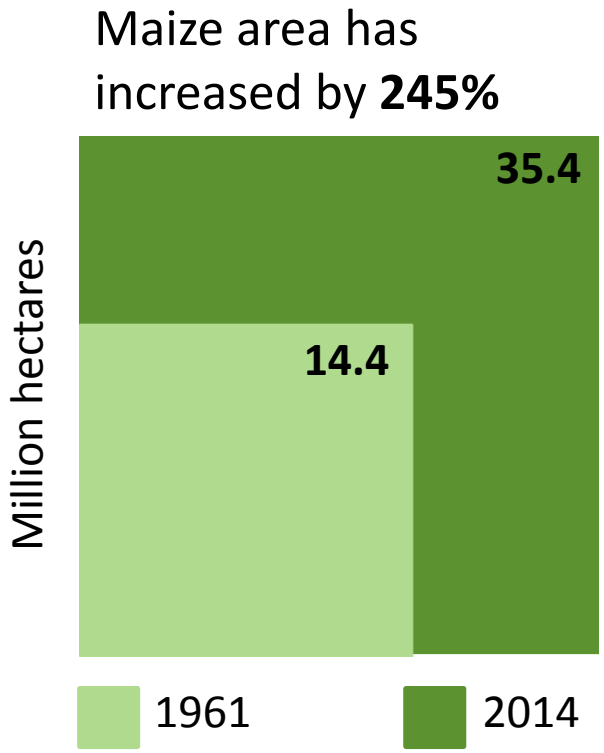
Low nitrogen = 0.62%

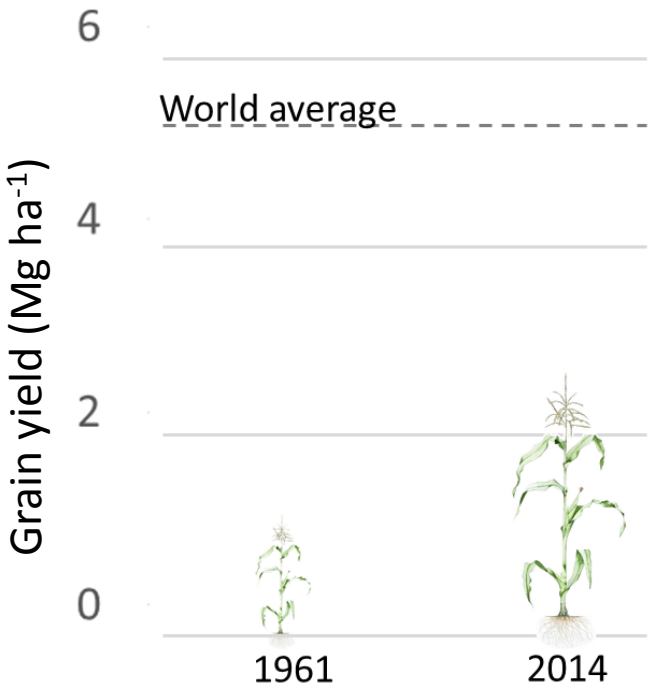
Maize streak virus= 2.2%

Comparable with other breeding programs worldwide

Masuka et al. 2017a and b

However maize yields remain low





Adapted from FAO, 2017

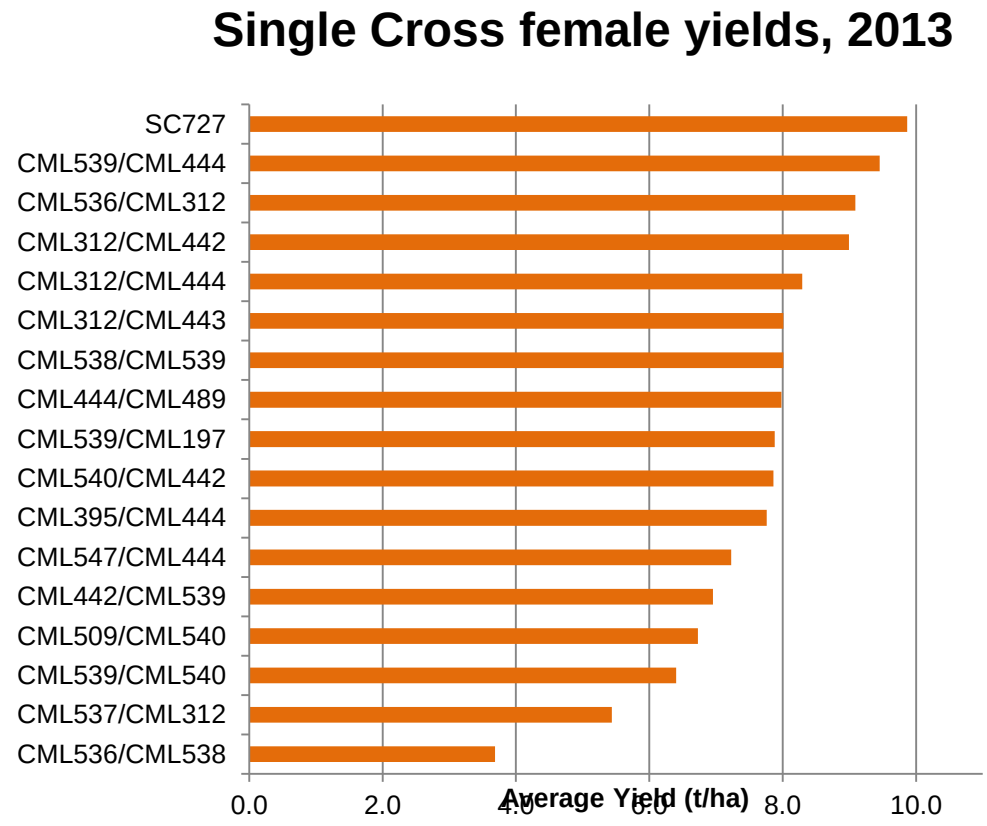
Maize production in sub-Saharan Africa increased **5-fold** since **1960s**

Mechanization and Automation of Breeding Operations

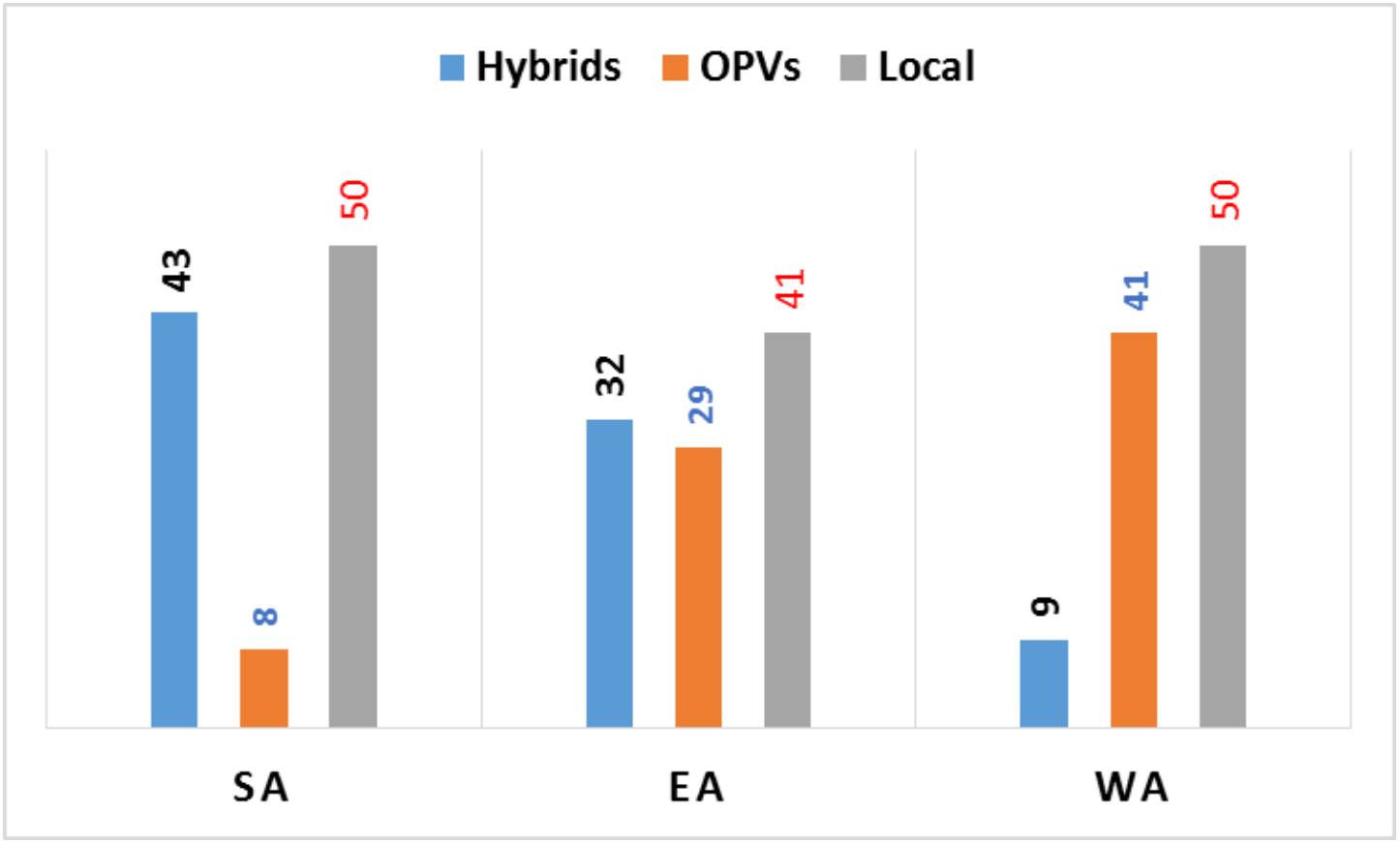
Nursery Rows	15,000 -> 50,000
Genotypes tested	25,000 -> 200,000
Annual trial rows	>100,000 ->500,000
Testing environments	5 -> 15+
Locations	20 -> 60+
Data Turnaround Time	80 -> 20

- Efficiencies realized in **seed preparation**
- Efficiencies realized in **electronic field data collection**
- Efficiencies realized in trial **harvest processing**

Seed production research



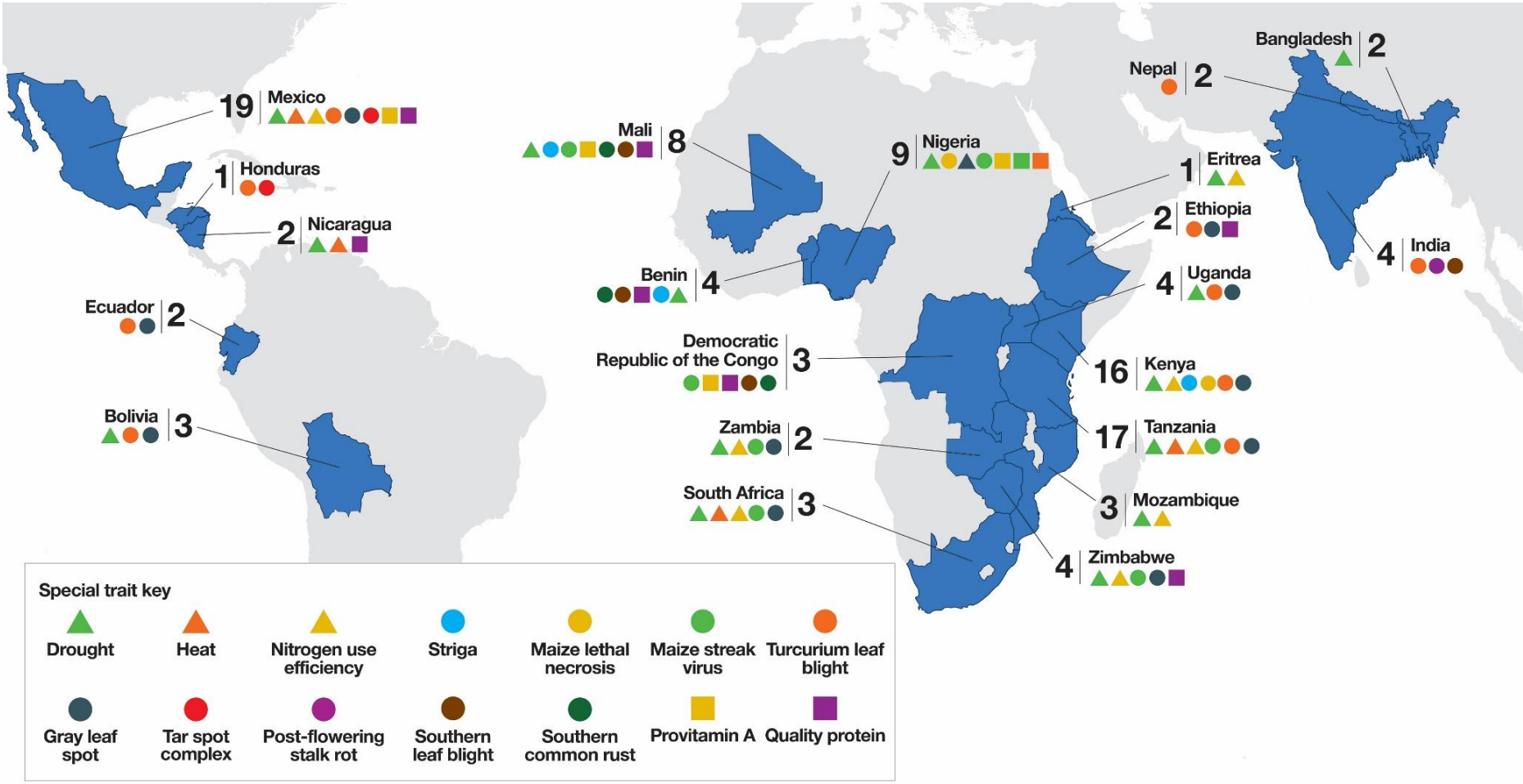
Percent proportion maize varieties by region



Abate et al., 2017

1700 maize varieties have been released between 1950-2014

2016 maize releases



Varieties commercialized by CIMMYT partners with traits preferred by smallholder farmers

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Variety Releases

2007-2014

>200 drought-tolerant and nutrient use-efficient maize varieties were released by >**100 companies in 14 countries.**

First MLN tolerant varieties commercialized in east Africa in 2016.

100,000 families growing and eating pro-vitamin A enriched maize.

First heat tolerant varieties commercialized in southern Africa in 2014

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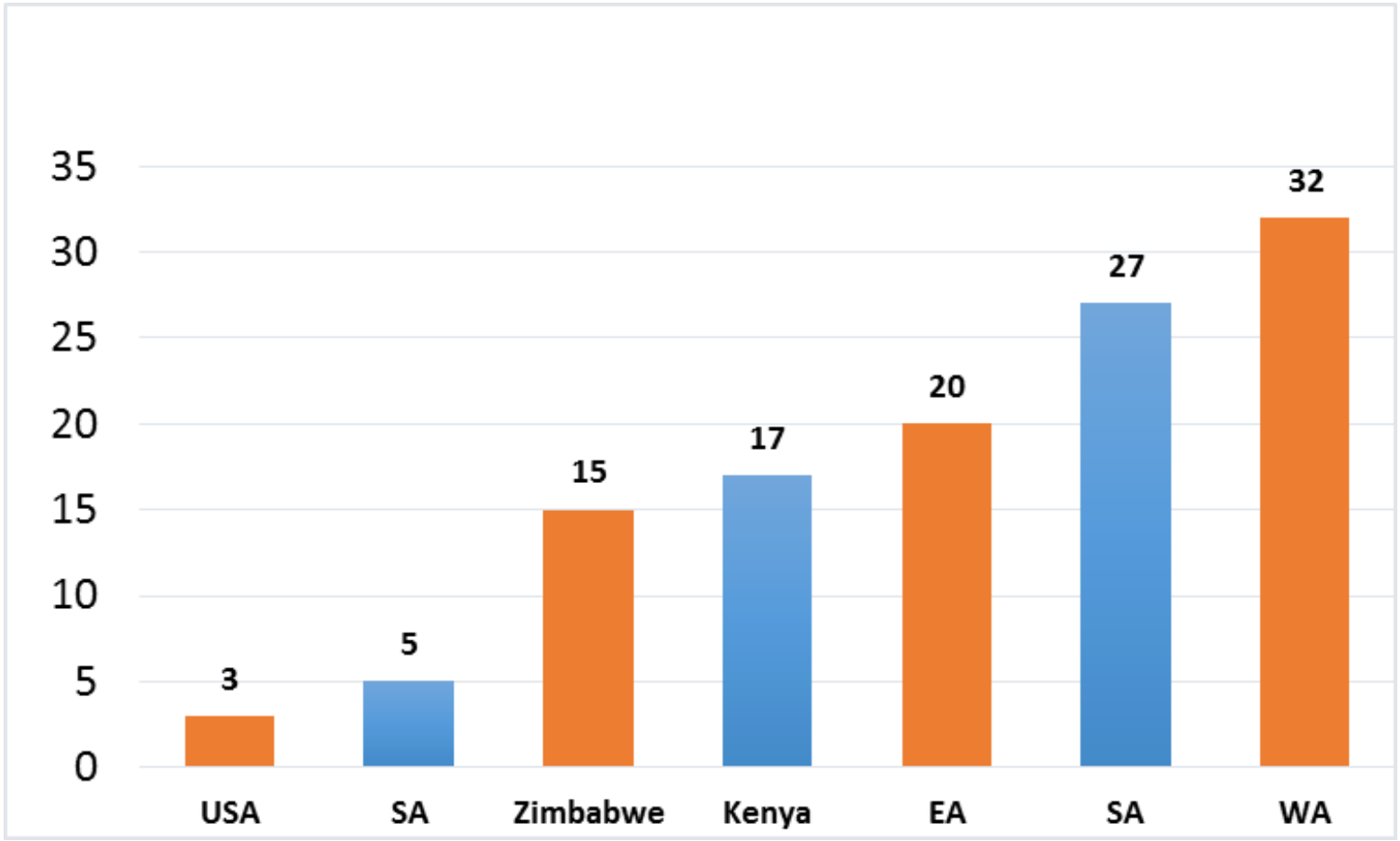
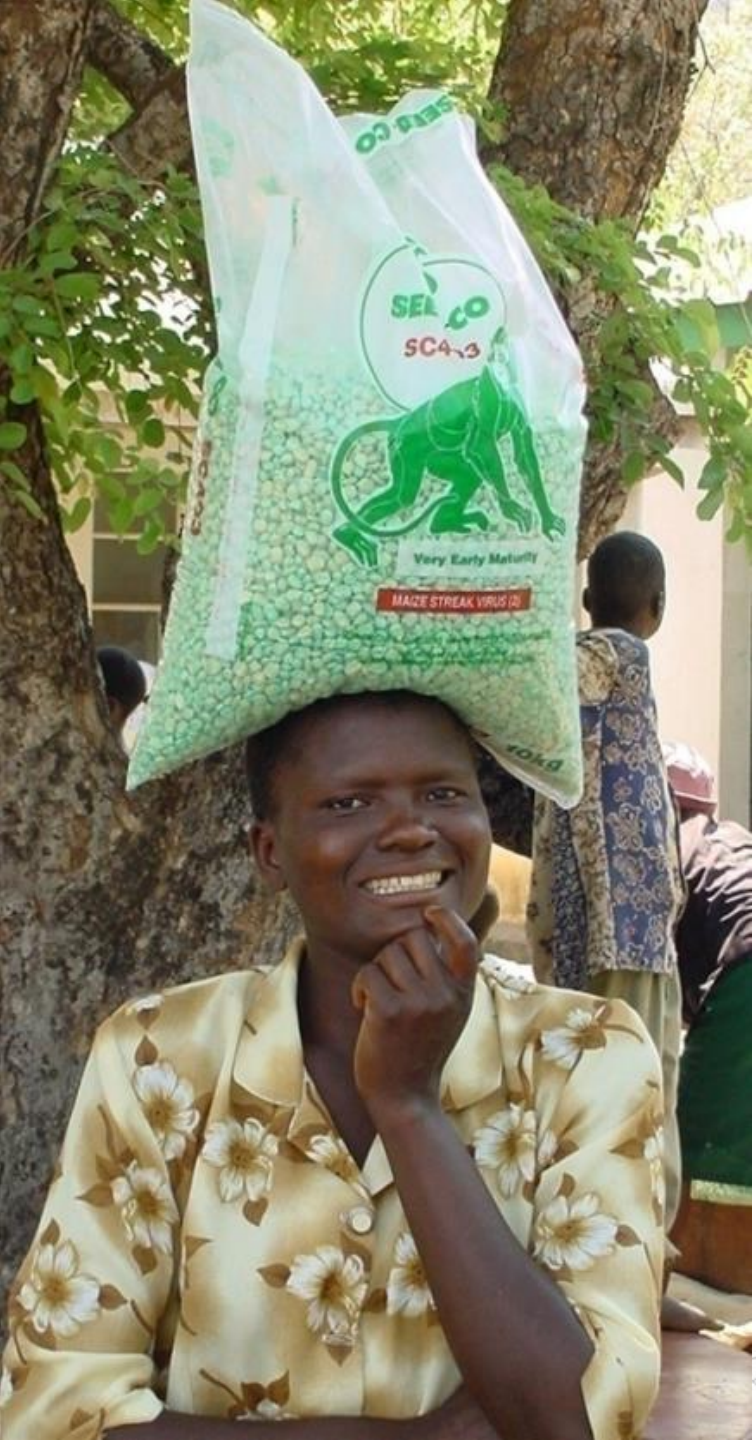
Accelerating variety replacement





Seed trade

- Seed market is valued at US$ 800 million which US$ 500 million is maize
- U$250 million horticulture (2% world share)
- Adoption rate of improved seed is estimated at 40%

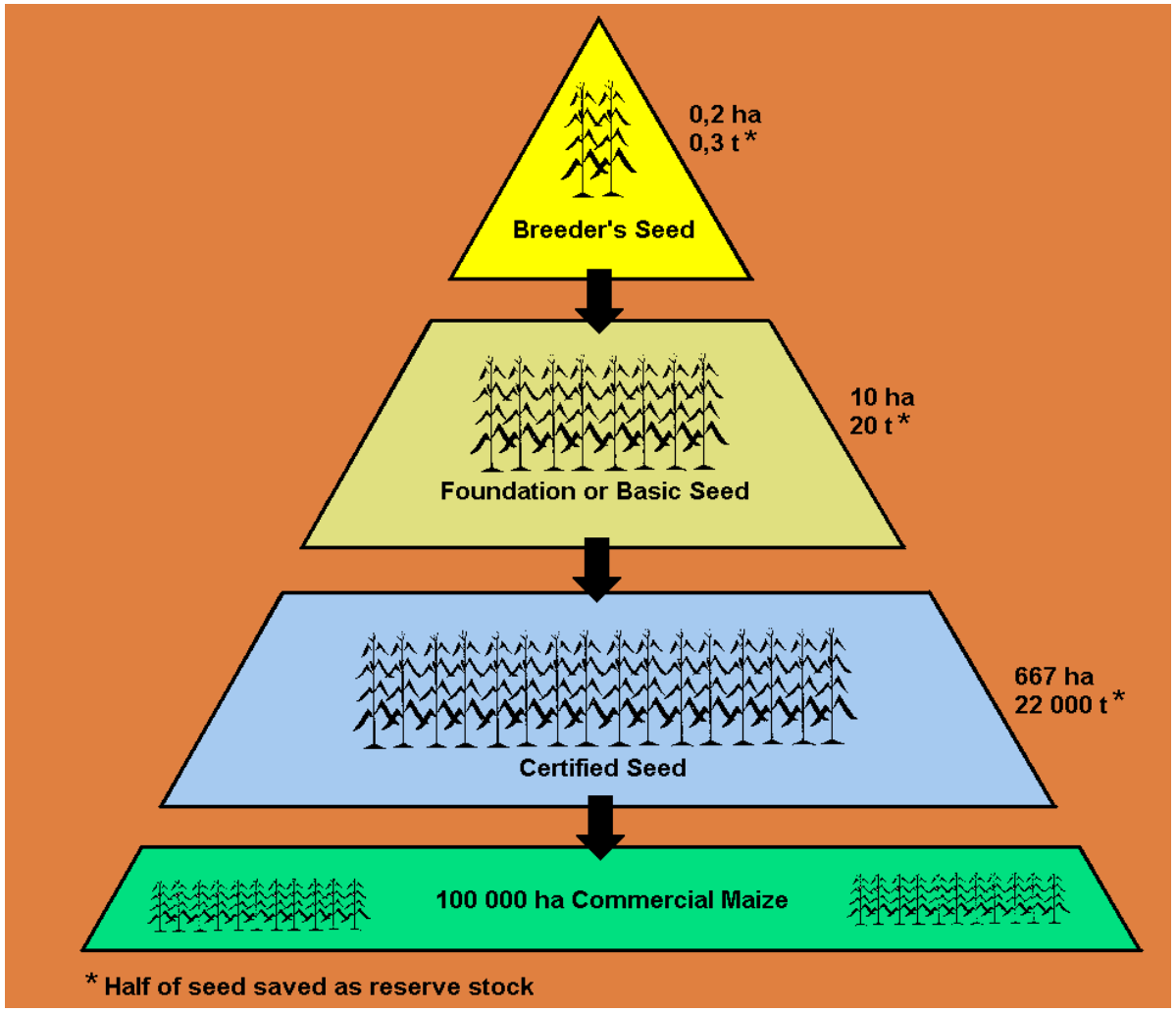
Many of the hybrids on the market in have CIMMYT germplasm

- CIMMYT is the largest contributor of improved maize germplasm annually as international public goods.
- Over 54% of publicly bred maize varieties released in the developing world are reported to have CIMMYT's elite maize germplasm

The Seed: a living organism

- Higher value = more care & inputs
- - Higher quality & genetically pure
    - Greater care in selection
    - Careful preparation of seed production fields
- - Consider seed sales, labor availability

Seed Classes



- Breeders' Seed
  - Controlled pollination
  - Small quantities
- Pre-Basic/Basic Seed
  - Extra-isolated fields
  - Strict quality standards
- Certified Seed
  - Isolated fields
  - High quality standards

Seed quality declines from Breeders Seed through to Certified Seed

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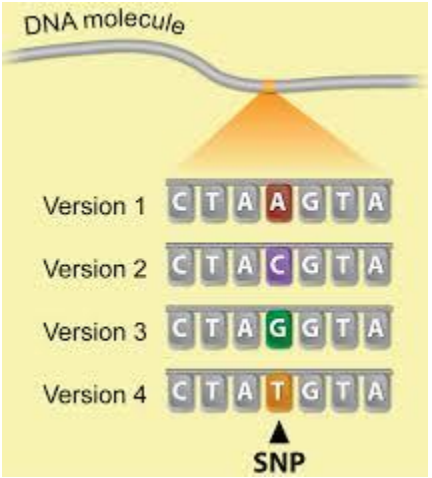
Variety maintenance

Increasing pure seed stock of a variety forever while avoiding contamination or genetic drift

Applications of molecular markers in QA/QC



SNP	Line 1	Line 2	
PHM5805_19	C:C	C:C	
PZA02698_3	**A:G**	A:A	
PZA03606_1	T:T	A:A	
PZA02462_1	A:A	C:C	
PZA02191_1	**A:G**	G:G	
PZA00770_1	C:C	G:G	
PZA01530_1	A:A	T:T	
PZA01062_1	A:A	A:A	
PZA02763_1	T:T	C:C	
PZA00222_7	**A:T**	A:A	

1. **Identification of genetic purity**
2. **Parent-off spring identity**
3. **Genetic purity of hybrid seed lots**
4. **Validation of crosses in nurseries**
5. **Trait-specific testing of seeds**

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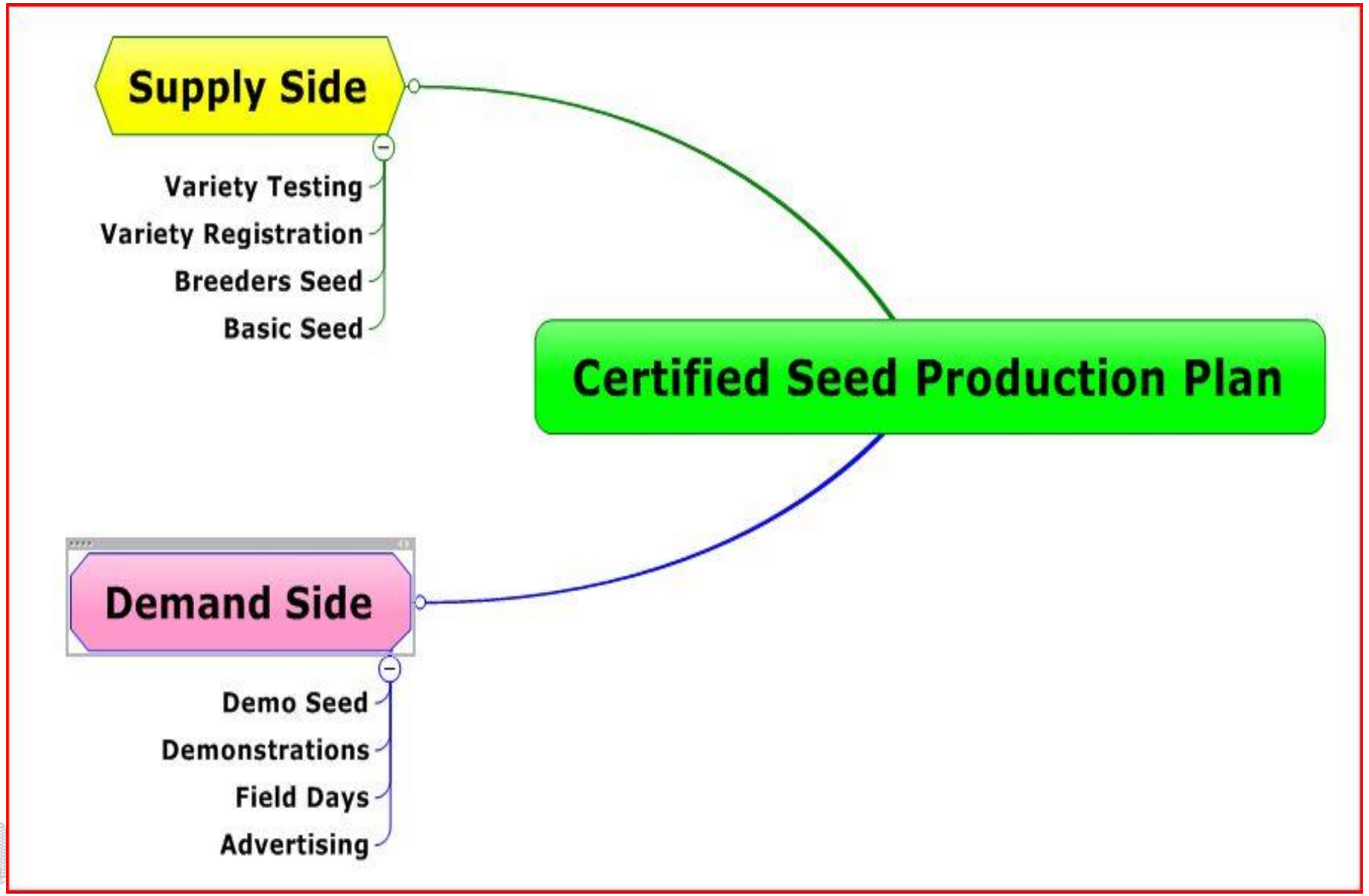
Theor. Appl. Genet. 125: 1487-1501 (2013)

Seed Road Maps



Capacity building of partners

10,000 days training given each year.

Technician Training

Breeders Training

Visiting Scientists

Ph.D./MSc students

More than 1,000 scientific and professional alumni around Africa.

Technician Training in Zimbabwe

Breeders Training in Zambia

Conclusions

- Efficiency gains made in the last decade
- New methods and tools incorporated into breeding
- New emerged challenges tackled with tangible outputs

Thank you!



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