Seed Crop Breeding and Challenges to Seed Production in Africa – the CGIAR Experience

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Outline

- CGIAR
- CIMMYT
- Seed and food security in Africa
- Challenges in seed production in Africa – The maize example
  - Structural challenges
    - The seed industry in Africa (History and evolution, Access to germplasm, Sources regulation, Regional/National organization, Financial support)
  - Technical challenges
    - Crop breeding and its products, Breeding nodes, Seed production research, variety turnover, technical capacity of seed company, Disease and pest control, QA/QC
- Concluding remarks

CGIAR - Mandate, Centers and CRPs

CGIAR is the only worldwide research partnership addressing agricultural research for development, whose work contributes to the global efforts to tackle poverty, food and nutrition insecurity, and environmental degradation.

CGIAR research is carried out by the 15 Centers with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector.

The “second generation” CGIAR strategy 2016–2030

- Guides the development and implementation of an ambitious portfolio of “second-generation” CGIAR Research Programs (CRPs)
- Focuses on selected grand challenges, and is articulated in 3 strategic goals, or System Level Outcomes (SLOs), which by 2030 will contribute significantly to the achievement of key Sustainable Development Goals (SDGs)
- Highlights a return on investment evaluated at US$17 for every US$1 put into CGIAR over its lifetime

Portfolio of 2nd generation CGIAR research programs

8 Agri-Food System programs

- Dryland Cereals and Legumes systems
- Fish agri-food systems
- Forest and Agroforestry landscapes
- Livestock agri-food systems
- Maize agri-food systems
- Rice agri-food systems
- Roots, tubers and bananas agri-food sys ns
- Wheat agri-food systems

4 Global Integrating programs

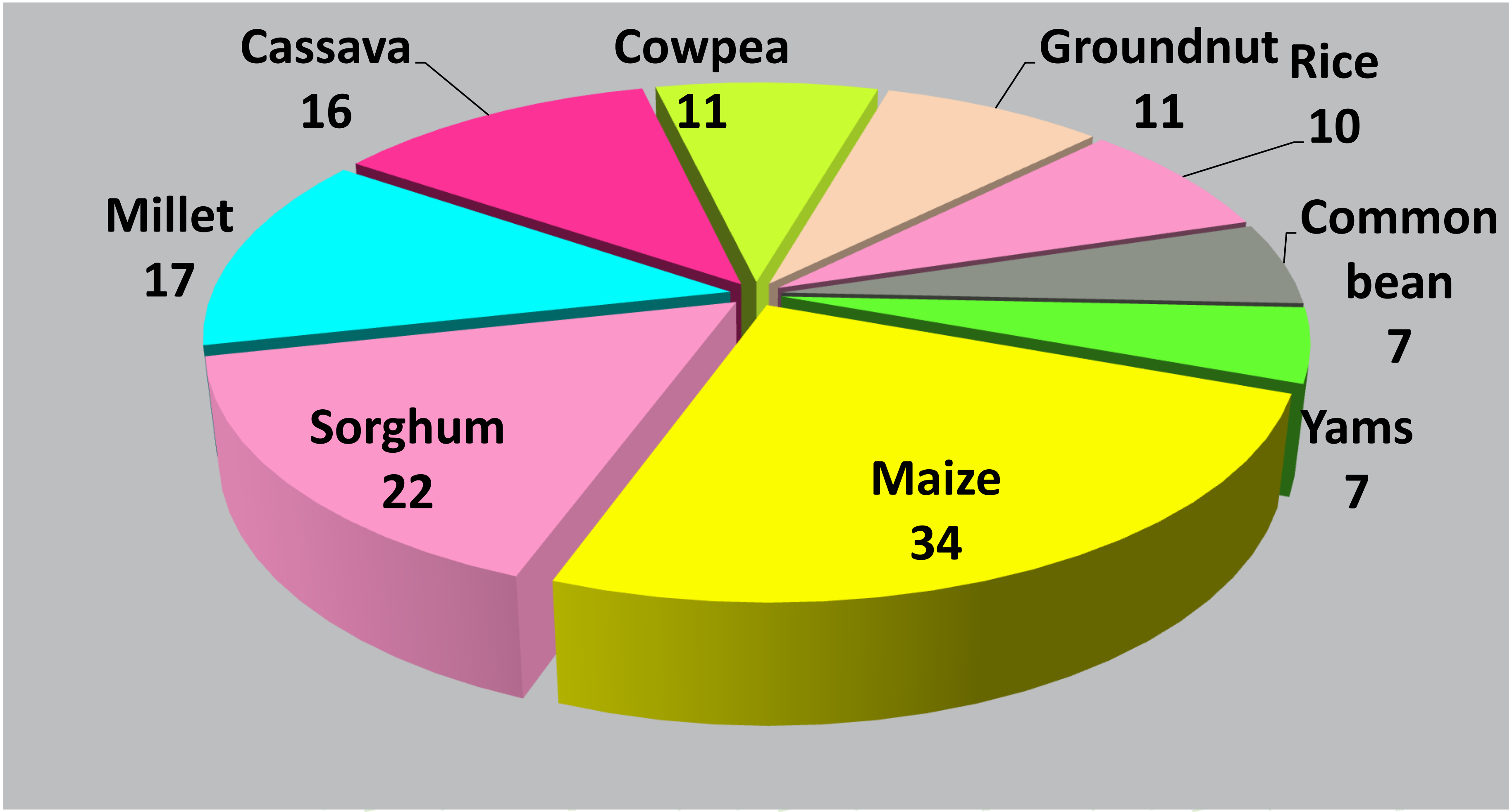
- NUTRITION & HEALTH
- PIM
- WLE
- CLIMATE CHANGE

3 Platforms

- Genebanks
- Genetic Gains
- Big data & ICT

Area occupied by major staples in SSA (2012-14)

- With 34 million ha, maize is the most widely staple crop in SSA
- An important source of food security and economic wellbeing in Africa



CIMMYT – Mandate, Offices, CRPs

Through collaborative research, partnerships and training, CIMMYT works throughout the developing world to improve livelihoods and foster more productive, sustainable farming.

CIMMYT Around the World

1200 staff from over 50 countries!

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CIMMYT in 2nd generation CGIAR research programs

8 Agri-Food System programs

- Dryland Cereals and Legumes systems
- Fish agri-food systems
- Forest and Agroforestry landscapes
- Livestock agri-food systems
- **Maize agri-food systems**
- Rice agri-food systems
- Roots, tubers and bananas agri-food systems
- **Wheat agri-food systems**

4 Global Integrating programs

- NUTRITION & HEALTH
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3 Platforms

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Major Achievements

Generate $3.5 – 4.5 billion in annual benefits to farmers in developing countries.

50% of maize and wheat grown in the developing world **based on CIMMYT varieties.**

10,000 researchers and professionals worldwide **alumni of CIMMYT training.**

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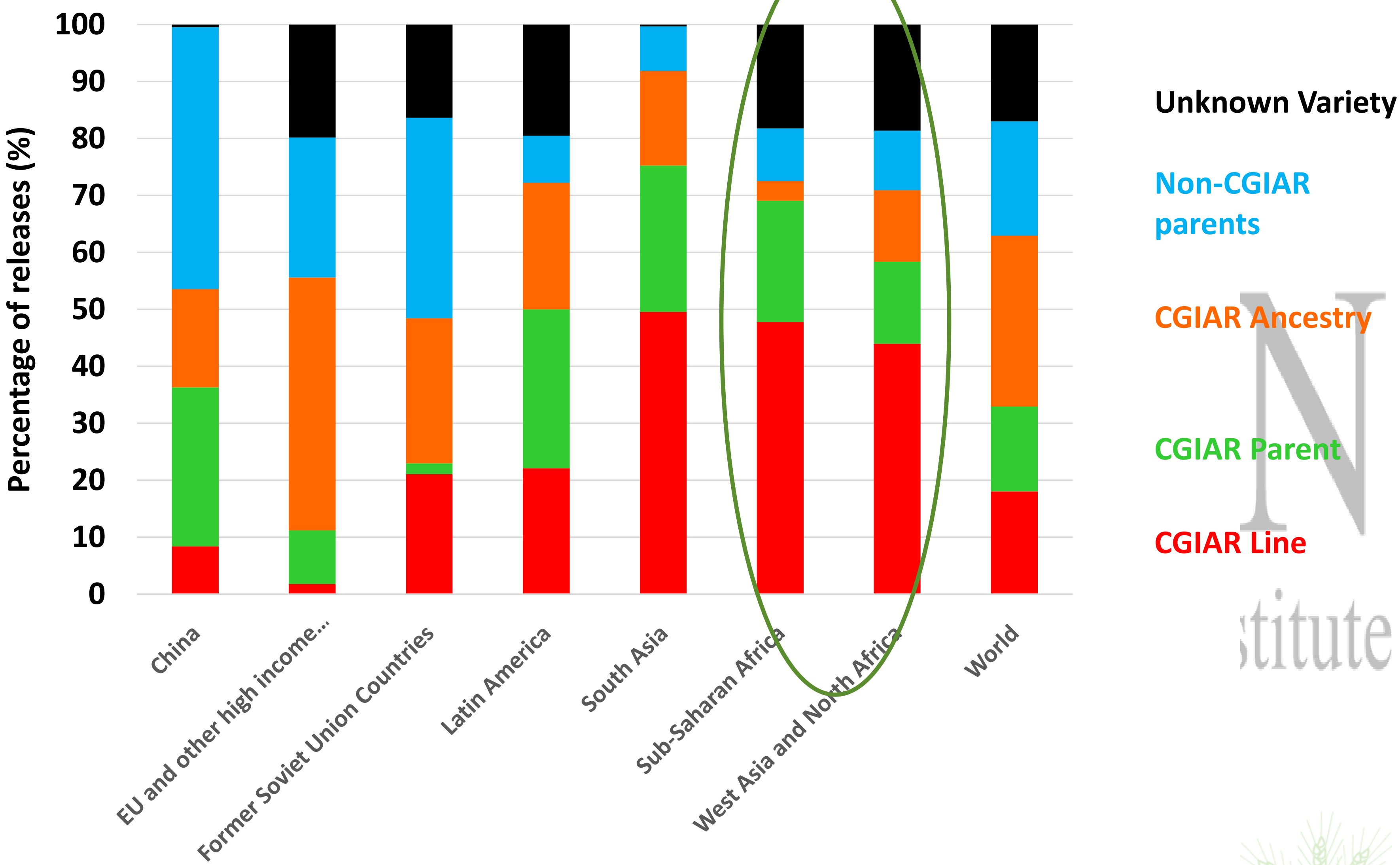
All wheat varieties releases by region and origin 1994-2014



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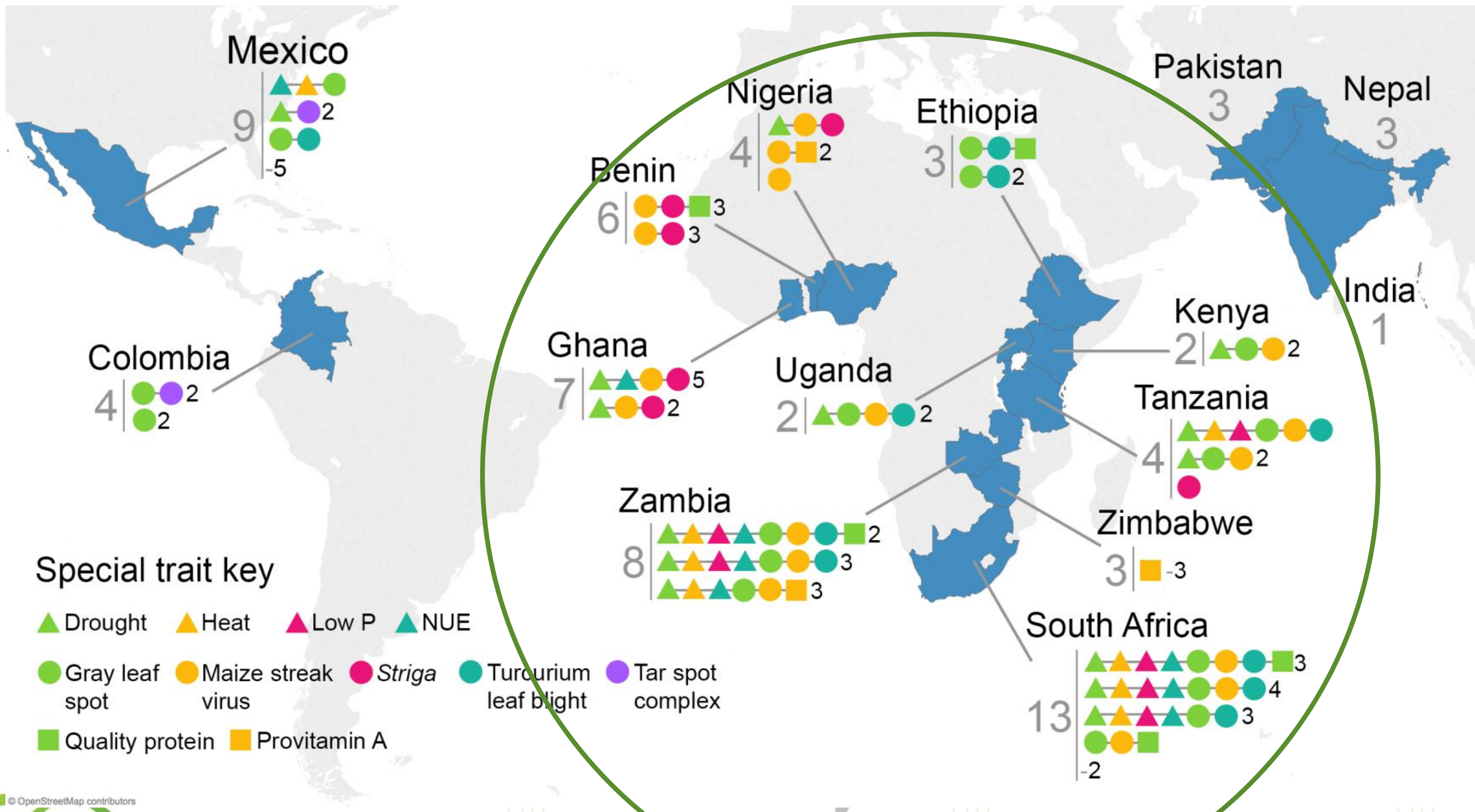
2015 maize releases

70 varieties commercialized by CIMMYT partners with traits preferred by smallholder farmers – based on available information only



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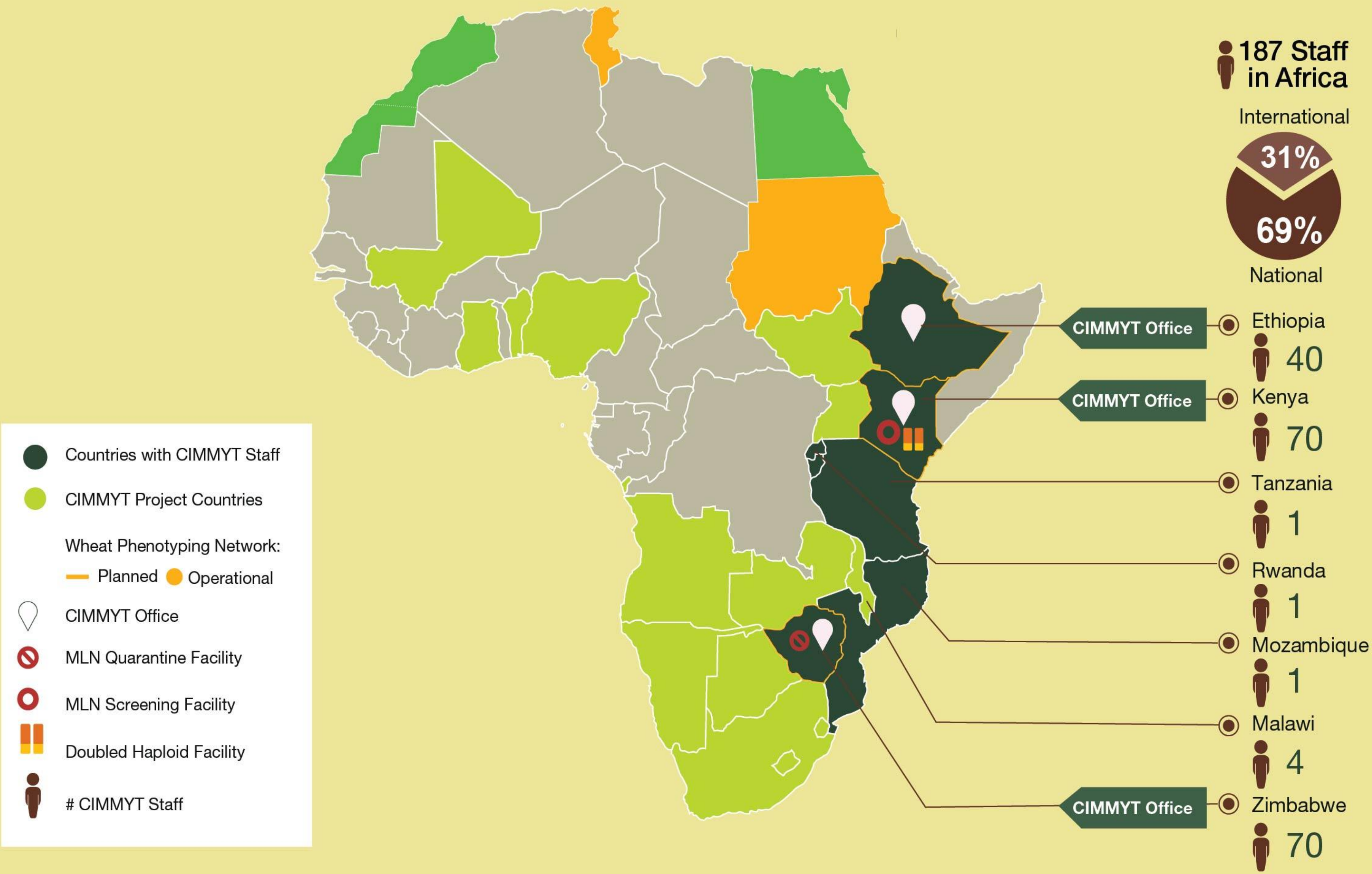
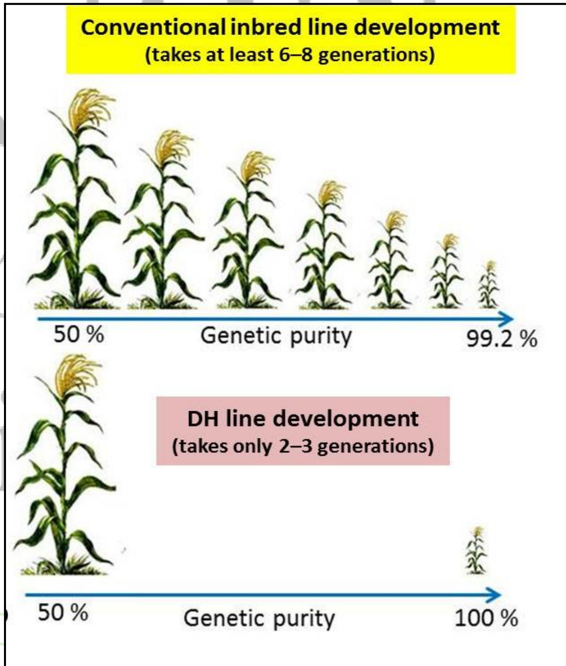
CIMMYT in AFRICA



Achievements

1. Germplasm developed (Trait sources, breeding germplasm transfer, variety releases).
2. Germplasm testing coordinated and enhanced (MWG / Project backstopping)
3. Seed of improved varieties produced (Support, seed production research)
4. Facilities that enhance development of stress resilient germplasm development developed (DH, MLN, Low-N sites, CFTs, Insectaries, PH labs etc..).
5. People trained (formal degree students, short term training, technical backstopping).



Maize and Wheat Production in Eastern Africa (2013)

Country	Production (Tons)		Productivity (t/Ha)		Area Harvested (Ha)	
	Maize	Wheat	Maize	Wheat	Maize	Wheat
Ethiopia	7,234,955	4,231,589	**3.42**	**2.54**	2,114,876	1,663,845
Kenya	3,513,171	328,637	1.66	**2.23**	2,116,141	147,210
Burundi	127,829	5,628	1.32	0.58	97,242	9,766
Rwanda	480,000	67,730	1.92	**2.19**	250,000	30,990
Tanzania	6,737,197	167,000	1.60	0.97	4,200,000	171,380
Uganda	2,763,000	22,000	**2.50**	1.57	1,105,000	14,000

This situation has to change and its changing

Crop Breeding and Seed production

Seed and food security in Africa

- Seed is essential for crop production and food security
- Except for seasons following crop failures, the lack of seed of improved varieties does not mean no planting by farmers
  - Significant seed recycling in Africa
  - Improved seeds can help small farmers increase their production six-fold (AGRA 2017)
- Africa's seed industry is complex and can be inefficient
- The demand for improved seeds in Africa exceeds supply
- Seed sets the upper limit of crop production potential
  - Returns to investments in other inputs are limited by seed potential

Crop Breeding and Seed production

Crop breeding for seed security

The success of a seed system is dependent on a productive and efficient crop breeding system

- Supply high yielding stress tolerant, nutritive cultivars that are suitable for seed production

In the past:
Number of improved crop varieties generated

Shift to

Today:
Demonstrated impact in farmers' fields

Strong seed systems needed to

- Reduce time to release new varieties
- Deploy easy-to-produce hybrids
- Rapid seed scale-up
- Gender and social inclusion

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Seed Production in Africa

- Challenges in seed production in Africa – The maize example
- **Structural and Technical Challenges**
  - Structural challenges
    - The seed industry in Africa
      - History and evolution
      - Legislation and regulation
      - Size of seed industry
      - Ownership of seed companies
      - Focus and reach of seed companies (National / Regional / Multinational)
      - Access to germplasm

Seed Production in Africa

- Challenges in seed production in Africa – The maize example
- **Structural and Technical Challenges**
  - Technical challenges
    - Crop breeding and its products
    - Hybrid Reproducibility (Seed production research)
    - Variety turnover
    - Technical capacity of seed company
    - Early generation seeds (EGS)
    - Disease and pest control
    - Quality assurance / Quality control (QA/QC)

Seed Production in Africa

CIMMYT Maize Seed Systems Specialist

- Maintenance and quality assurance of all key parents (widely used CMLs, coded lines, and SX hybrids)
- Develop seed road-maps and strategies
- Implement seed production research and provide seed production recommendations
- On-farm trials / Field Days in collaboration with partners/collaborators for identifying/highlighting key products for commercialization
- Provide timely and active inputs for technology targeting, and feedback to breeders on product advancement and customer/end-user requirements
- Assist in data generation for variety registration (VCU & DUS), wherever required.

Structural challenges in seed production in Africa

1. History and Evolution

- Government parastatals -> Government seed companies
  - Limited growth
  - OPVs -> hybrids; Self pollinated vs cross pollinated crops
  - Protected market
  - Government control vs market control
  - Regional and multinational seed companies restricted
- Liberalization of seed industry started in the 1990s

Structural challenges in seed production in Africa

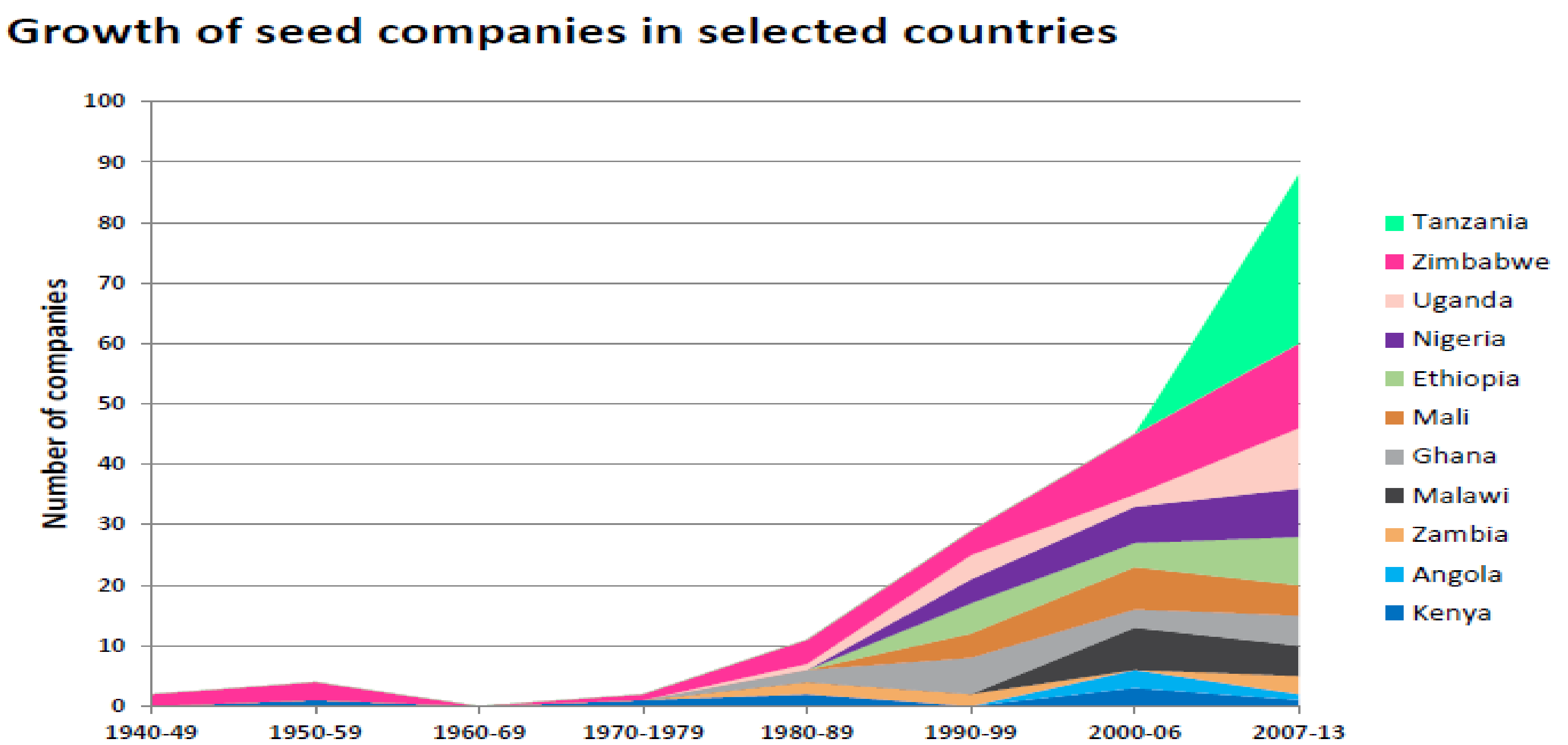
2. Regulation

- National seed and other policies
- Regional policies
  - Ranges from no regulation to over regulation
  - Affects cost of seed
  - Affects speed to market

Structural challenges in seed production in Africa

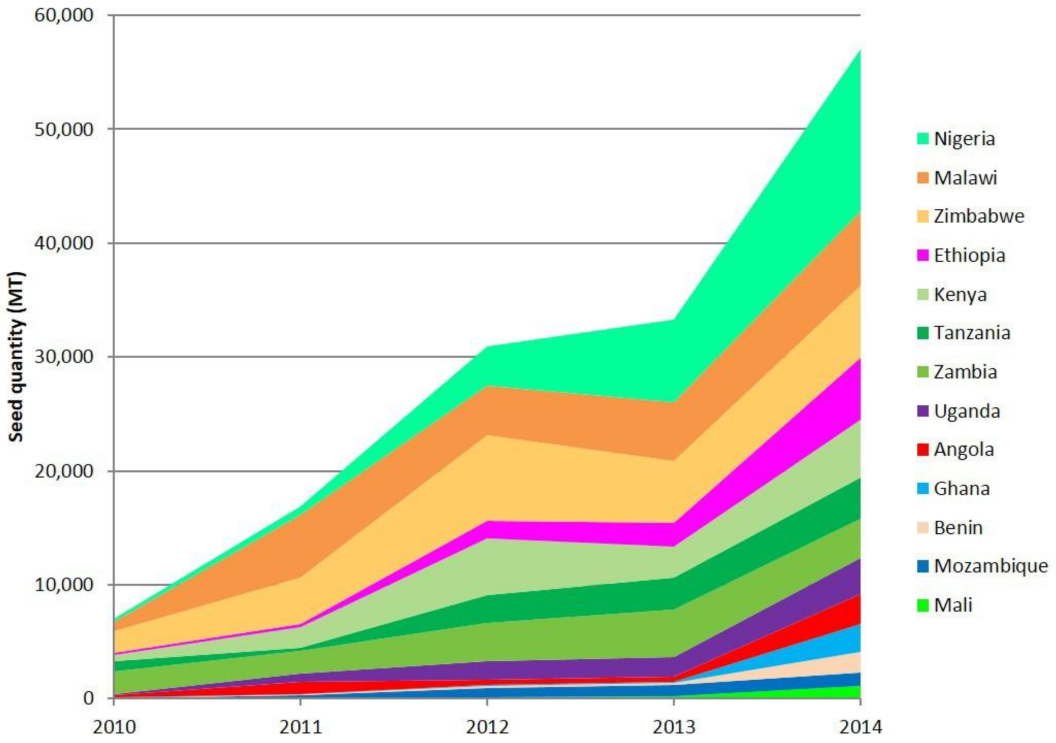
3. Size of seed industry in Africa

- Small, but has seen tremendous growth in the last 25 years (Demand for seed, availability of varieties, Targeted support)



CIMMYT works with ~100 local, regional and large seed companies in Africa (from 11 companies in 1996)!

- Diverse products for diverse ecologies and markets
- Diverse partners with diverse germplasm needs (and trait combinations)



Improved maize varieties are indeed the driver behind the growth of seed sector in Africa!

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Structural challenges in seed production in Africa

4. Resource base (Financial and facilities)

- Varies by seed company
  - National seed companies
  - Large multi-national seed companies
- Scope and reach

Structural challenges in seed production in Africa

5. Access to germplasm

- Seed company own breeding program
    - Few seed companies have breeding programs
    - Few seed companies have breeding programs in Africa
- Licensing from public or private sector

CIMMYT/CGIAR Varieties available to seed companies

- **CIMMYT/CGIAR centres do not release any "variety". Partners (public /private) release CIMMYT/CGIAR products (hybrids or improved OPVs) as "Varieties", following national rules and regulations.**
- CIMMYT/CGIAR responsibility is to develop improved germplasm (inbred lines, hybrids, improved OPVs) and deploy these through partners (public/private).
- CIMMYT has an open and transparent policy on how CIMMYT-derived products (hybrids/improved OPVs) are allocated to the partners, based on defined criteria and process of allocation.

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Pathways for release of CIMMYT-derived Improved Maize Varieties

Breeding new maize varieties	CIMMYT, NARS
Regional Trials, ROFT	CIMMYT, NARS, Seed companies
Variety release, registration (DUS, VCU)	NARS, Seed companies
Basic & Certified Seed Production	NARS (for basic seed only), Seed companies
Varietal Promotion and dissemination	Seed companies

Technical challenges in seed Production in Africa

1. Crop breeding and its products

- Farmers deserve the most improved seed for god production
- Seed companies also want to invest in highly productive varieties demanded by farmers.
- CIMMYT developed stress resilient, highly productive and b nutritious maize and wheat varieties

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Challenges for Smallholders in the Tropics

Climate change
drought, flooding, heat

Biotic stresses
new cropping systems
disease/pest pressure

Water & Nutrients
water tables; surface water
fertilizer cost; imbalanced use

Soils
Degradation, erosion
nutrient deficiencies

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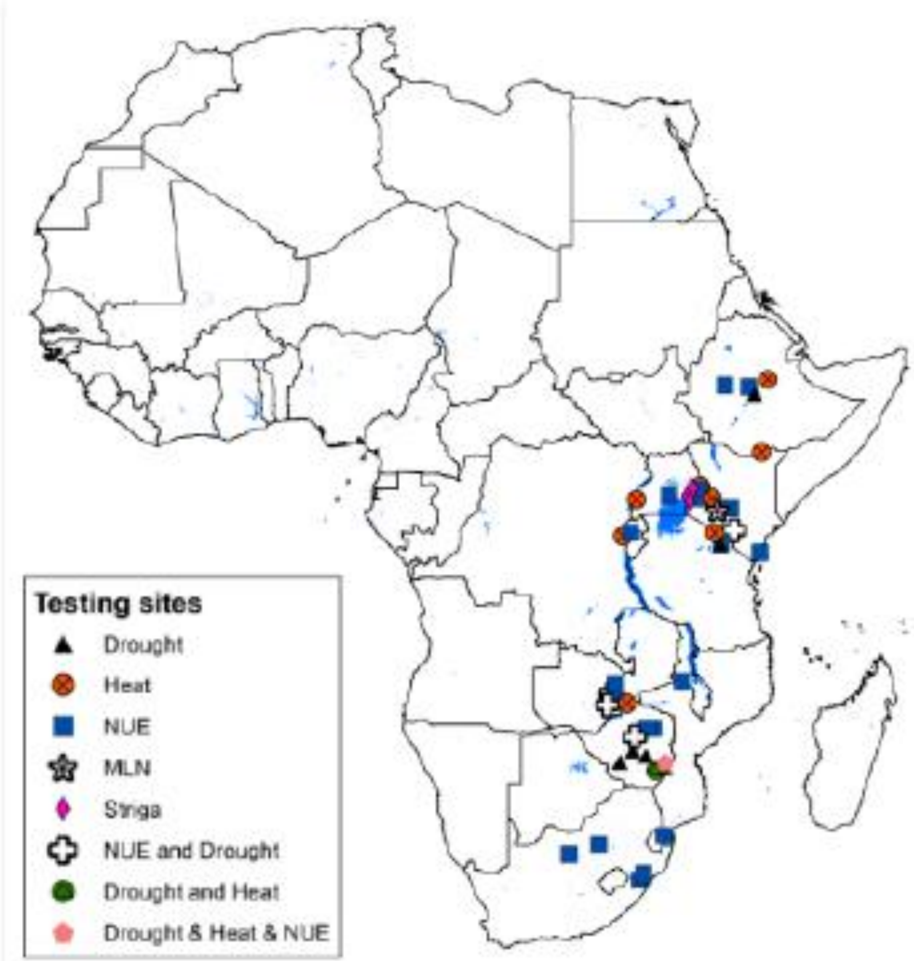
Perhaps the strongest managed stress screening network in sub-Saharan Africa



Drought* - 61 ha

Low nitrogen - 48.5 ha

Heat - 13.5 ha

MLN - 17 ha

*Including CFT sites

550 sets of **regional trials** screened annually in SSA

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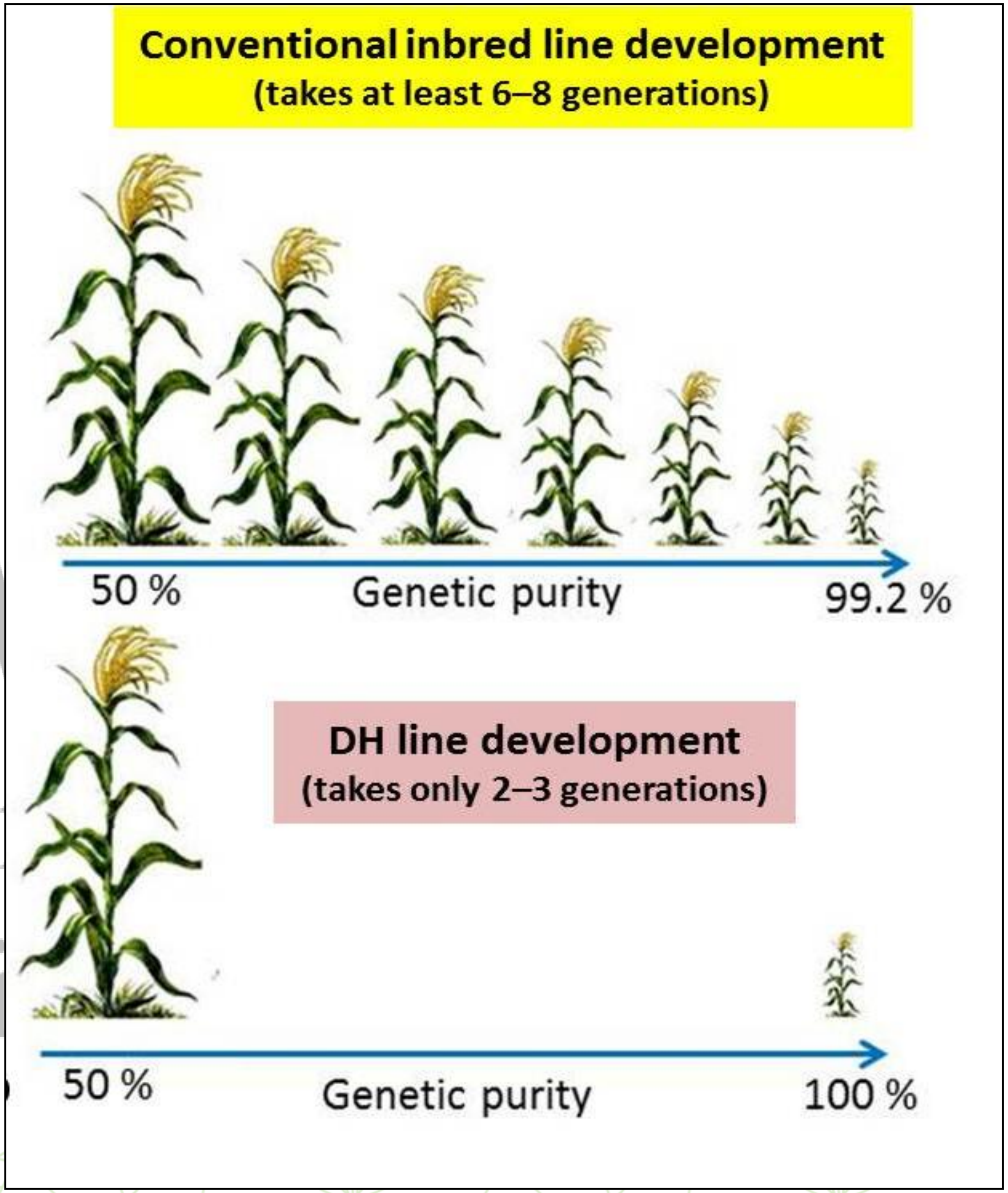
New tools: Doubled Haploid Technology



Technical challenges in seed Production in Africa

3. Hybrid producibility

Seed Production Research Targets generating the following key information required by seed producer for successful production of hybrid seed

- Areas of adaptation of both female and male parents
- Female seed yield
- Nicking (planting split and pollination)
- Female agronomics (height, standability & disease reaction)
- Female seed characteristics (quality, size)
- Male pollen production (duration & quantity), tassel height & agronomics

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Herbicide screening: Reaction of popular IL lines

CML395

Control

Acetochlor

Bromoxynil

Halosulfuron

Nicosulfuron

Topramezone

CML444

Control

Acetochlor

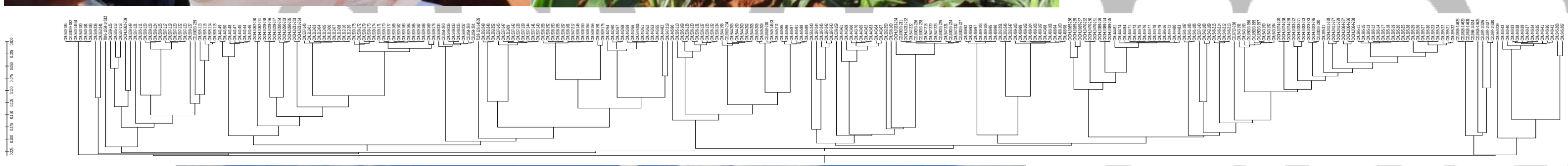
Bromoxynil

Halosulfuron

Nicosulfuron

Topramezone

CIMMYT SS group work with molecular breeders, breeders and partners in purity and identity test of CIMMYT inbred lines used by different partners, breeders….



Kiboko, 2014

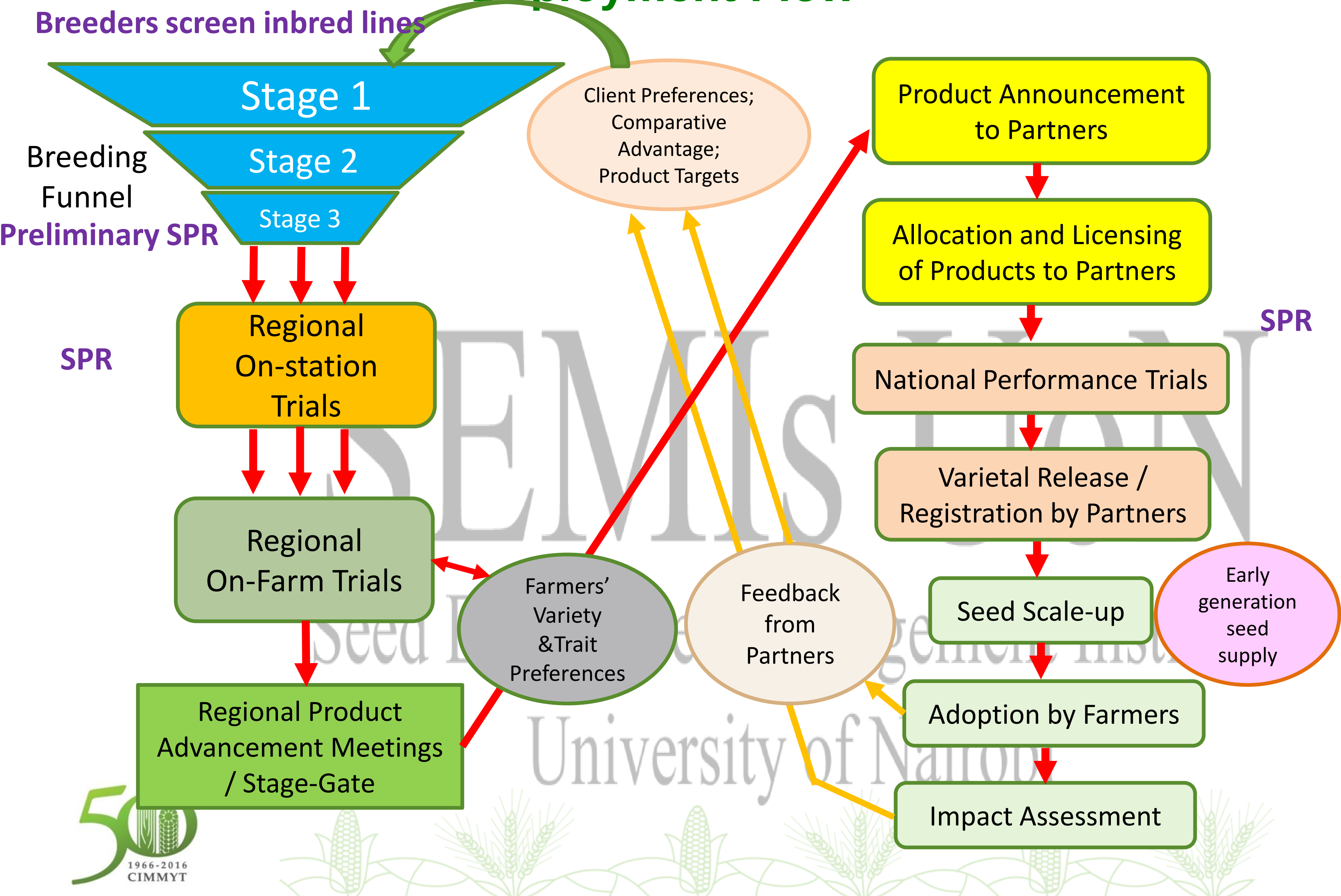
Used both descriptor and molecular data

Discarded stocks with problem

Seed Production Research

- SPR at different stages facilitates elimination of hybrids with seed production problems before release
- SPR assists in the generation of information required for seed production of new hybrids
- Screening inbred lines for sensitivity to locally available herbicides is advisable.

SPR in CIMMYT Elite Maize Product Development and Deployment Flow



Technical challenges in seed Production in Africa

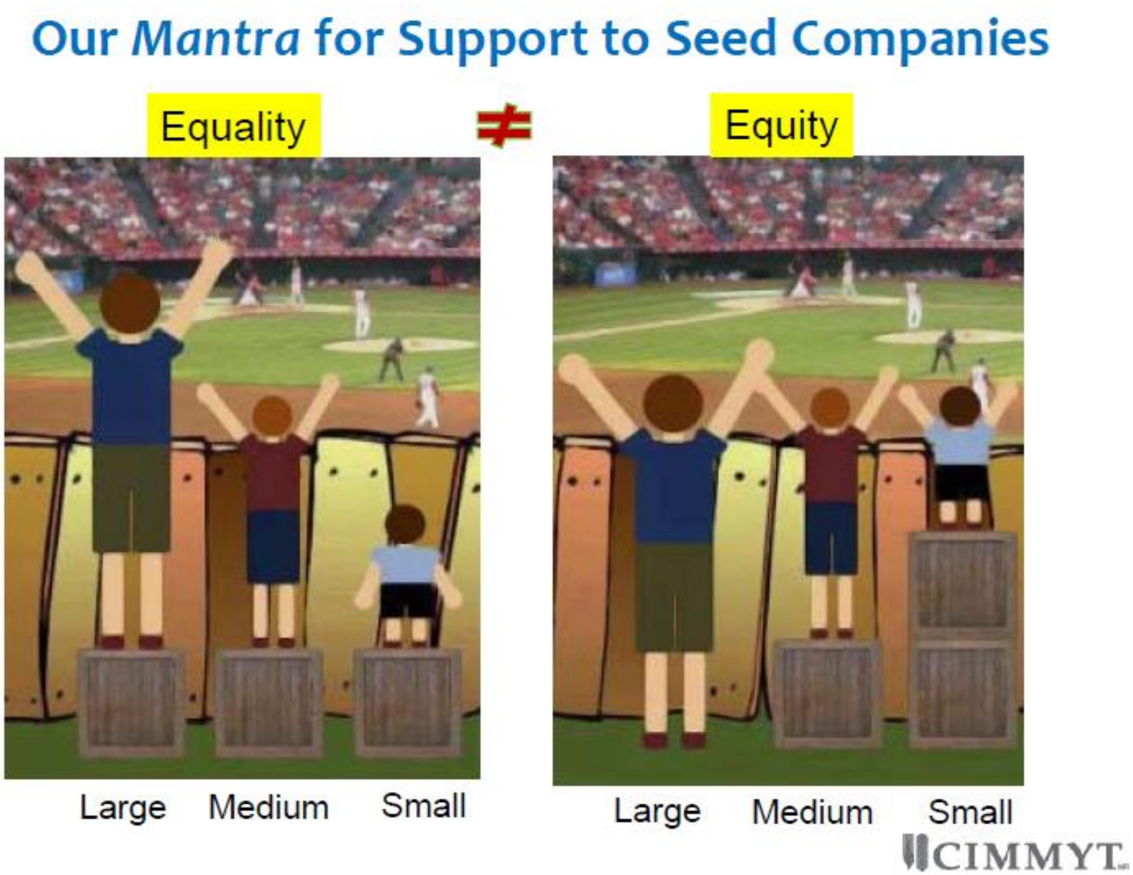
4. Variety turnover

Variety turnover in SSA is slow:

- 49% of all maize area in SSA is covered by varieties that are >19 years old;
- 57% of area in southern Africa is under varieties that are >21 years old;
- 57% of area in eastern Africa is under varieties that are >14 years old;
- 32% of area in West Africa is under varieties that are >20 years old.

Technical challenges in seed Production in Africa

5. Technical capacity of seed company



Support

- Training
- Technical back stopping
- Information (Hybrid performance, hybrid producibility, hybrid descriptors etc.)

Training/Capacity Building of Partners

CIMMYT is well-known internationally for its training programs on:

- Abiotic stress phenotyping
- Advanced maize breeding
- Breeding informatics
- Disease diagnostics and management
- Nutritional quality assays
- Aflatoxin analysis
- Doubled haploid technology
- Marker-assisted breeding
- Statistical and genomic analysis
- Hybrid seed production
- Seed business management
- Low-cost hermetic grain storage technologies

Technical challenges in seed Production in Africa

6. Early generation seeds (EGS)

- Breeder seed, basic/foundation seed increase usually do not generate revenue for seed companies immediately.
- EGS are expensive to produce as they require higher QA/QC and may require hand pollination

Technical challenges in seed Production in Africa

Possible models for EGS supply in SSA

- Selected public institutions in SSA supply private seed sector through
- legal mandate
- Selected public institutions supply the private seed sector through
- public-private partnerships
- Foundation Seed Initiative to supply FS through a cost recovery mechanism
- Selected private sector entity supplies FS to other seed companies through contractual commercial agreement (E.g. AATF led Qualibasic Seed Company)
- Seed companies produce their own FS

Technical challenges in seed Production in Africa

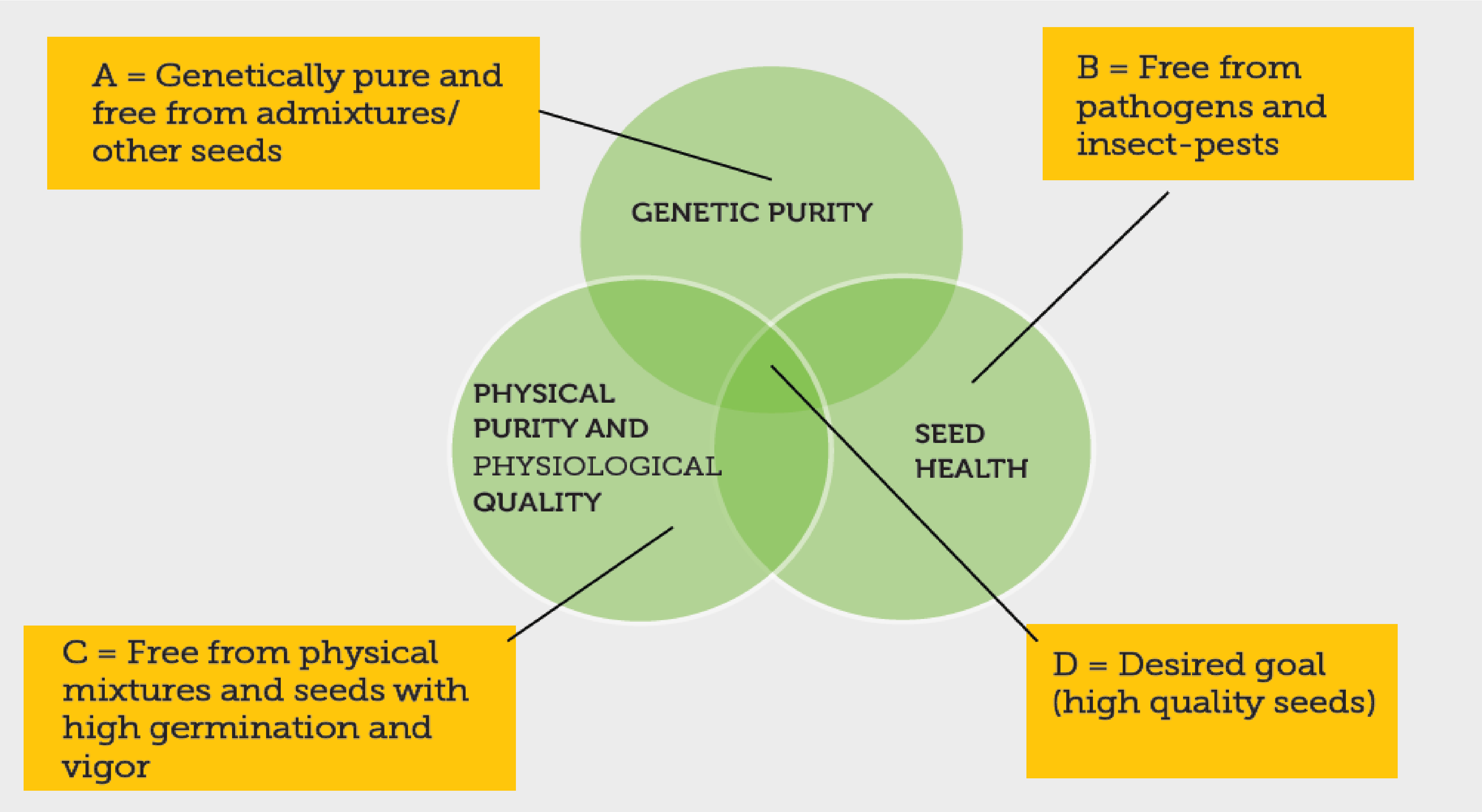
7. Disease and pest control

- Disease and pests resistant varieties
  - Breeding inputs (MLN, TLB for maize)
- Disease and pest control in seed production
  - MLN devastated seed production and seed distribution
  - FAW might equally affect seed production
- Disease and pest free seeds (see QA/QC)

Technical challenges in seed Production in Africa

8. Quality assurance / Quality control (QA/QC)

Quality Components of the seed



Technical challenges in seed Production in Africa

8. Quality assurance / Quality control (QA/QC)

Seed testing methods:

1. Germination
2. Seed viability
3. Seed vigor
4. Phenotypic and morphological traits based grow-out tests
5. Biochemical and / or molecular marker based testing.

Developing the seed industry in Malawi

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INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

4,500 tons or 54% of seed: Contribution to the Farm Input Subsidy Program (FISP) of the government in 2013, translated to:

- US$ 5.7 million per annum from seed and grain sales
- US$ 3.3 million worth of consumed legumes and grain in households
- 10-fold increase (42 tons in 2008 to 400 tons in 2014) in groundnut foundation seed production
- 8308 tons of improved groundnut and pigeonpea seed sold by the private sector local seed companies through the FISP

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A stronger and more diverse seed sector is vital for rapidly driving genetic gains in farmers' fields…

- **Efficient variety release and seed supply systems across SSA**
- **More rapid access by farmers to new varieties:**
  - Currently 5 to >>10 years
  - Widespread access in ≤ 5 years after development
- **Healthier and more diverse maize seed sector**
  - Growth of small companies beyond 1500 metric tonnes
  - Inclusive financing
- **QA/QC**: Quality Assurance/Quality Control through effective inspection and use of modern molecular tools

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Conclusions and looking at the future

- The future looks blight with increased interest in the seed industry.
- Need for capacity to handle novel traits
  - GMO and gene editing products
  - Adoption of technologies to improve efficiency of seed production
    - Ms44 Seed Production Technology for smallholder farmers in sub-Saharan Africa

For more resources visit: http://www.cimmyt.org/

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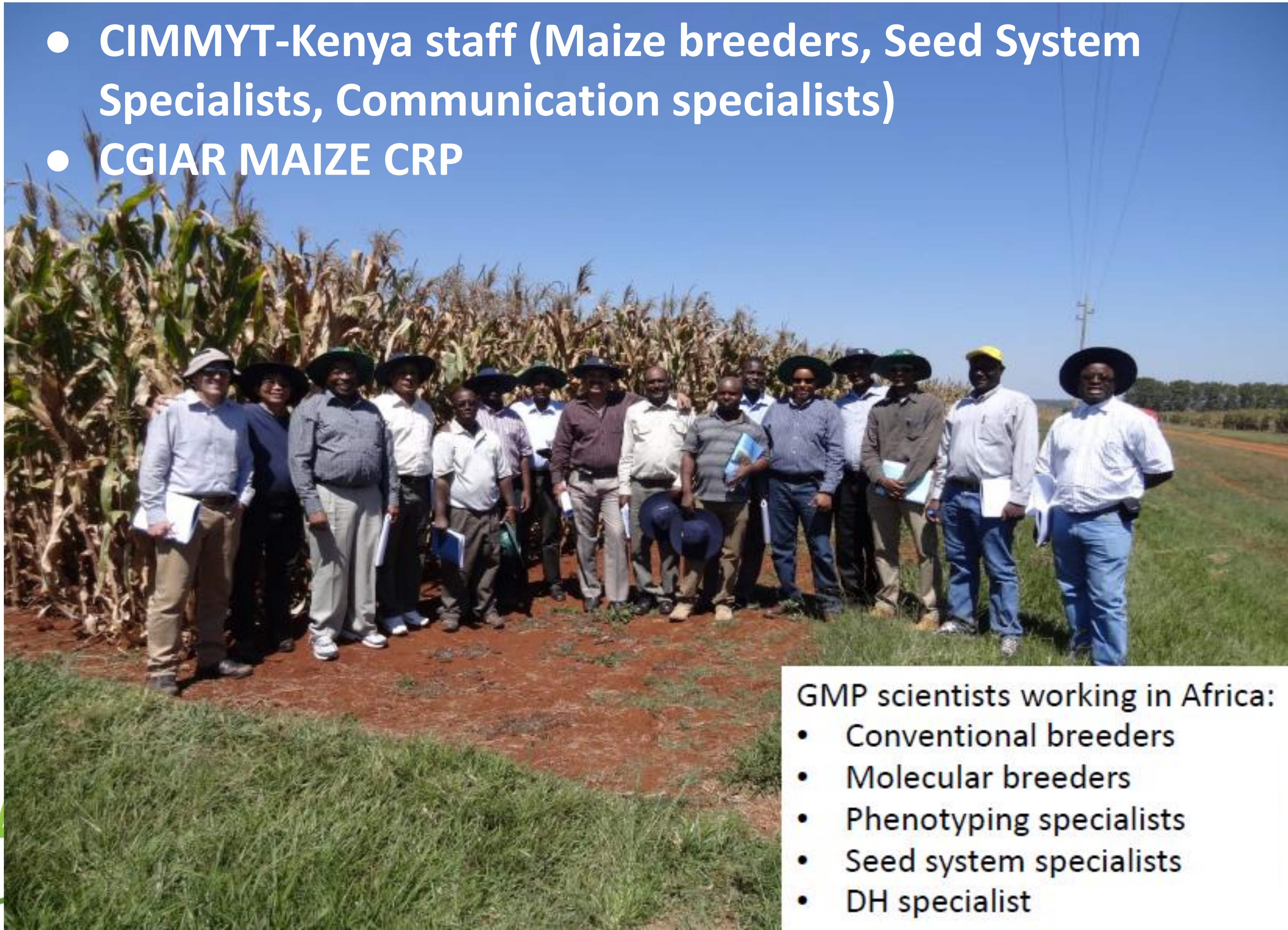
Acknowledgements

- CIMMYT-Kenya staff (Maize breeders, Seed System Specialists, Communication specialists)
- CGIAR MAIZE CRP



GMP scientists working in Africa:

- Conventional breeders
- Molecular breeders
- Phenotyping specialists
- Seed system specialists
- DH specialist

Thank you for your interest!

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