

Impacts of CIMMYT Maize Breeding in Sub-Saharan Africa

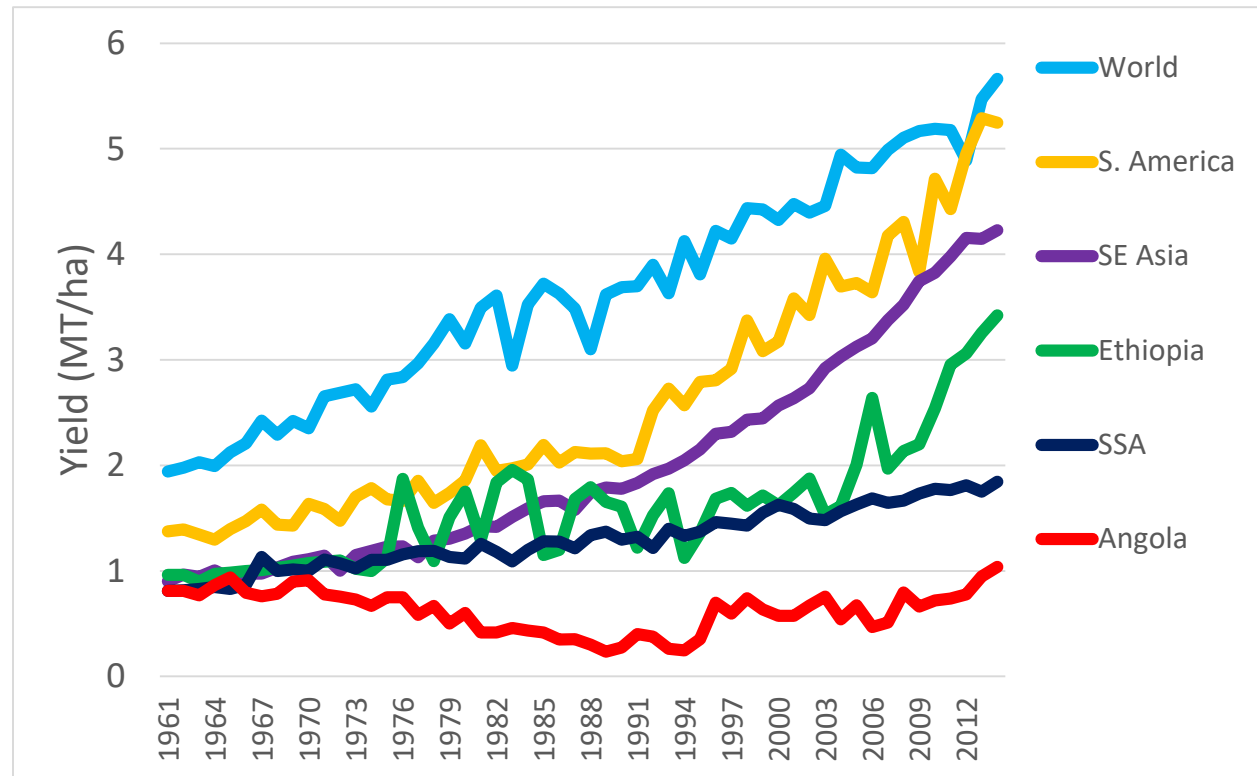
Yoseph Beyene
on behalf GMP-Africa Team
y.beyene@cgiar.org

Presentation to CIMMYT Global Maize Program Meeting Shanghai Academy of Agricultural Sciences, China September 18-20, 2019

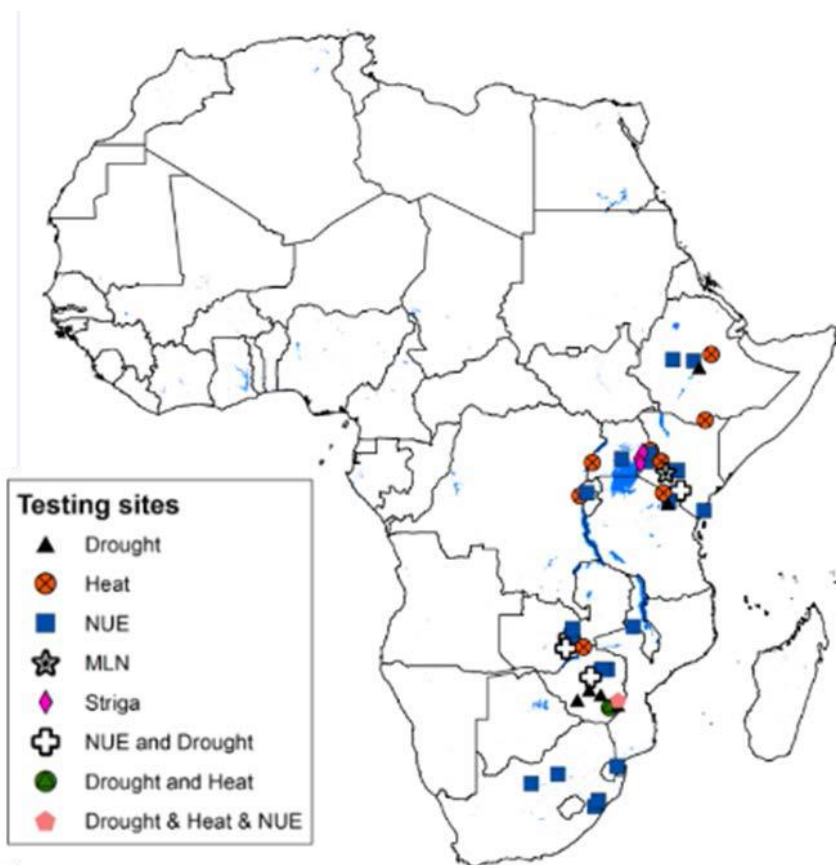


Maize in Sub-Saharan Africa

- Maize is life for most of Africa
- Grown on 36 million ha in SSA
- > 208 million farmers depend on maize
- Average yields in SSA are the lowest (<2 t/ha) in the world
 - Drought, Low N
 - Biotic stresses (MLN, FAW)



CIMMYT's extensive maize phenotyping network in Africa



updated from Prasanna et al. 2013



Drought - 61 ha



Low nitrogen - 48.5 ha



Heat - 13.5 ha



MLN - 17 ha



Breeding for stress tolerant maize in Africa



Managed drought-Kiboko



Optimum-Embu

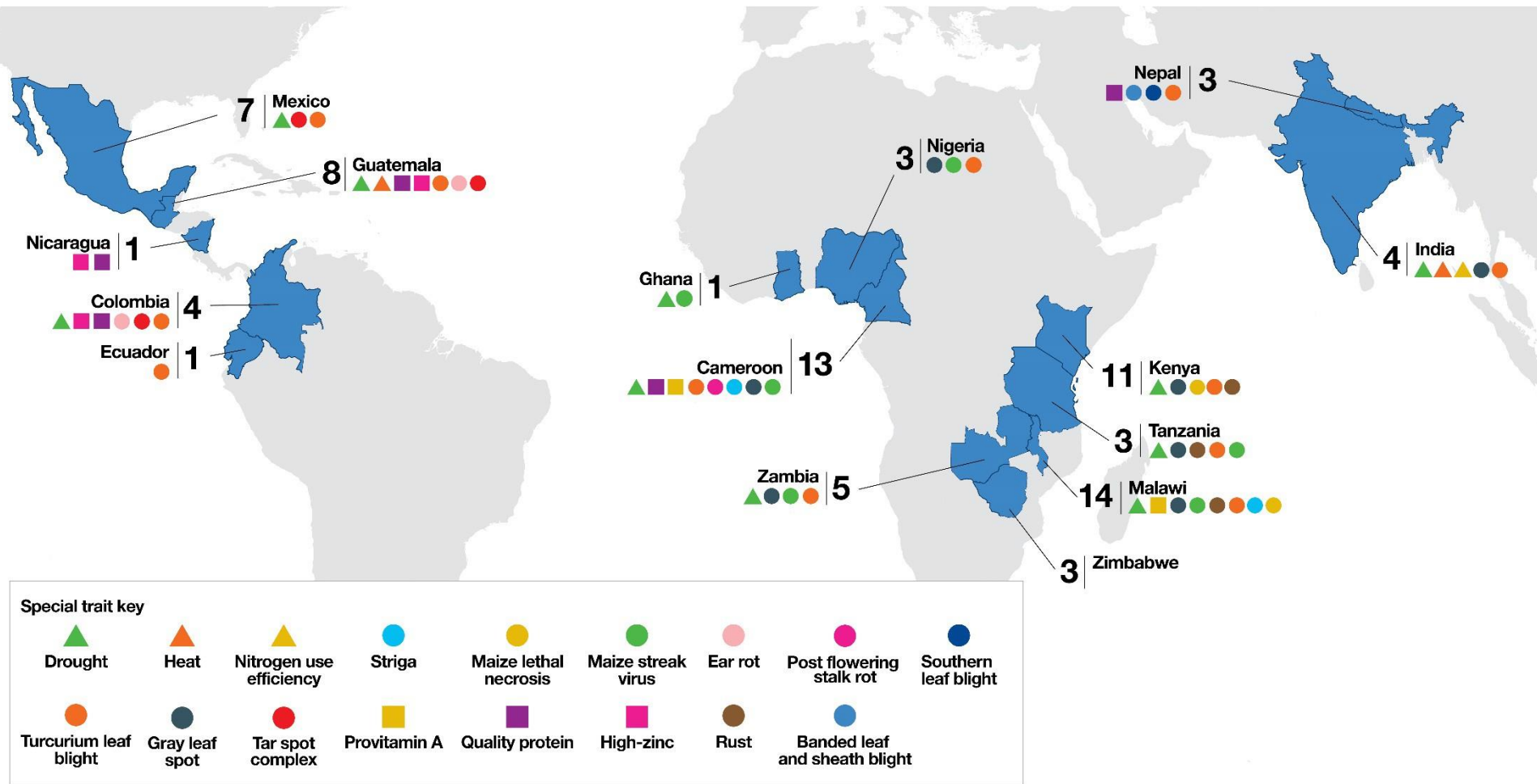


MLN-Naivasha



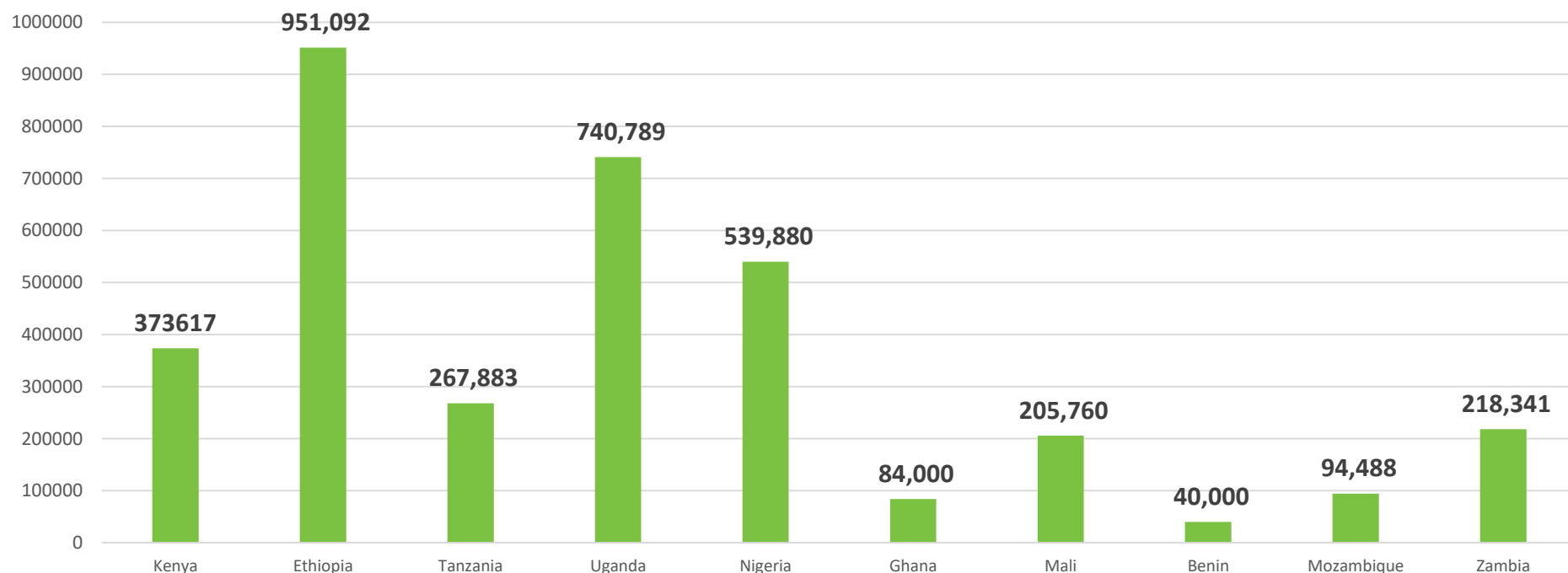
Turcicum leaf blight at Kakamega

MAIZE Varietal Releases in 2018



- **81 unique varieties released across Africa, Asia and LatAm in 2018** (63 varieties based on CIMMYT germplasm; 18 based on IITA germplasm)
- **14 varieties are Combination Hybrids** (majority from SSA)
- **20 of the released varieties are nutritionally enriched** (ProA/QPM/QPM+High Zn)

3.5 million smallholder farmers planted stress tolerant MAIZE varieties in 10 target countries in Africa (2018)



Breeding Progress for MLN Tolerance (2011-2019)



Commercial checks



KALRO-CIMMYT MLN Screening Facility at Naivasha, Kenya



MLN tolerant and susceptible hybrids Demo at Naivasha in 2019

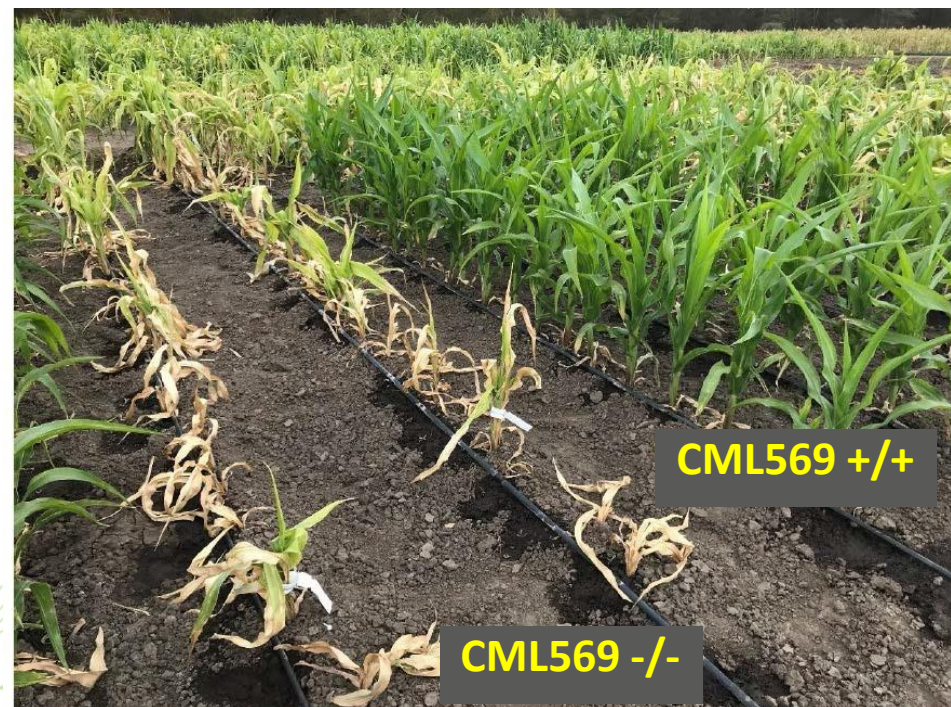
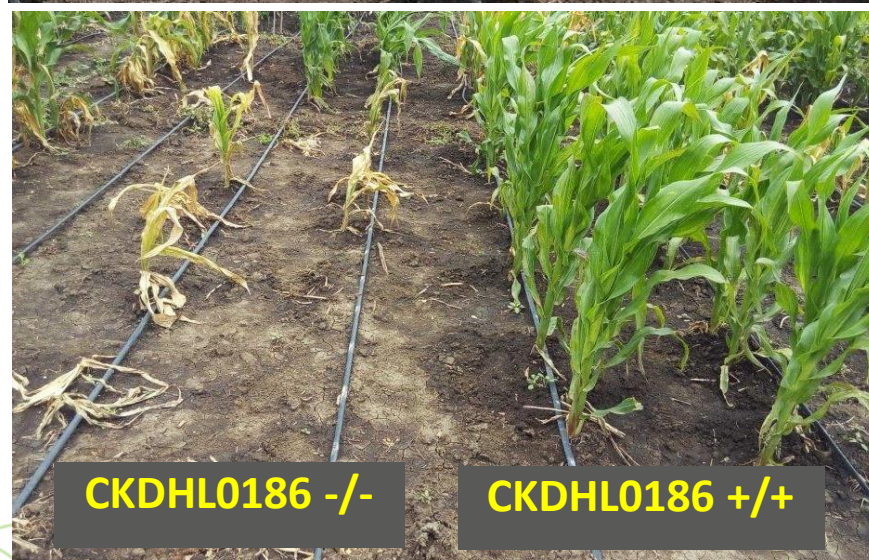


Commercial checks in 2019 demo



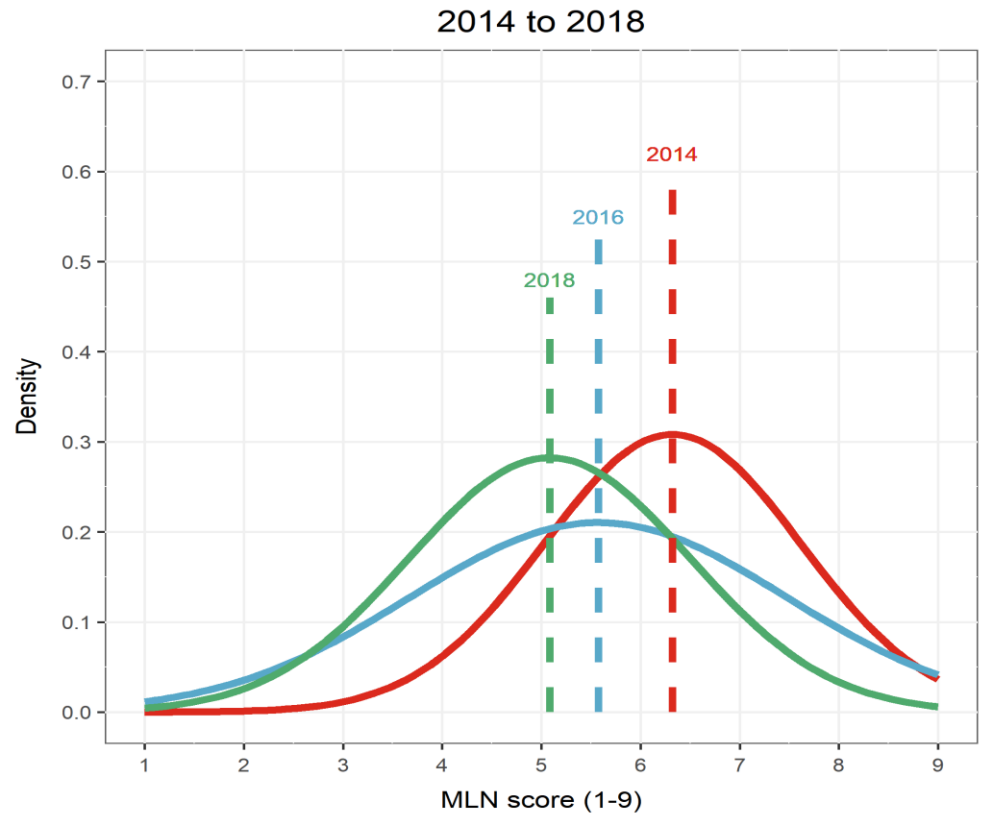
MLN tolerant hybrid in 2019 demo

MLN Resistance through MABC



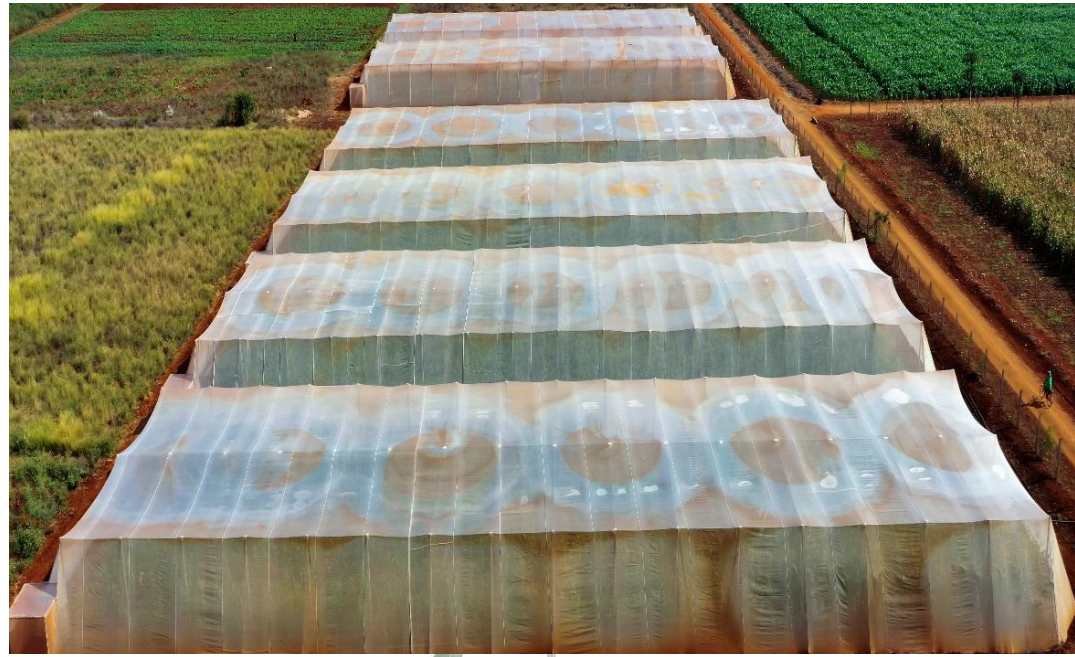
Breeding progress for MLN tolerance from 2014-2018

Year	# lines evaluated
2014	2876
2016	1522
2018	909
Total	5307



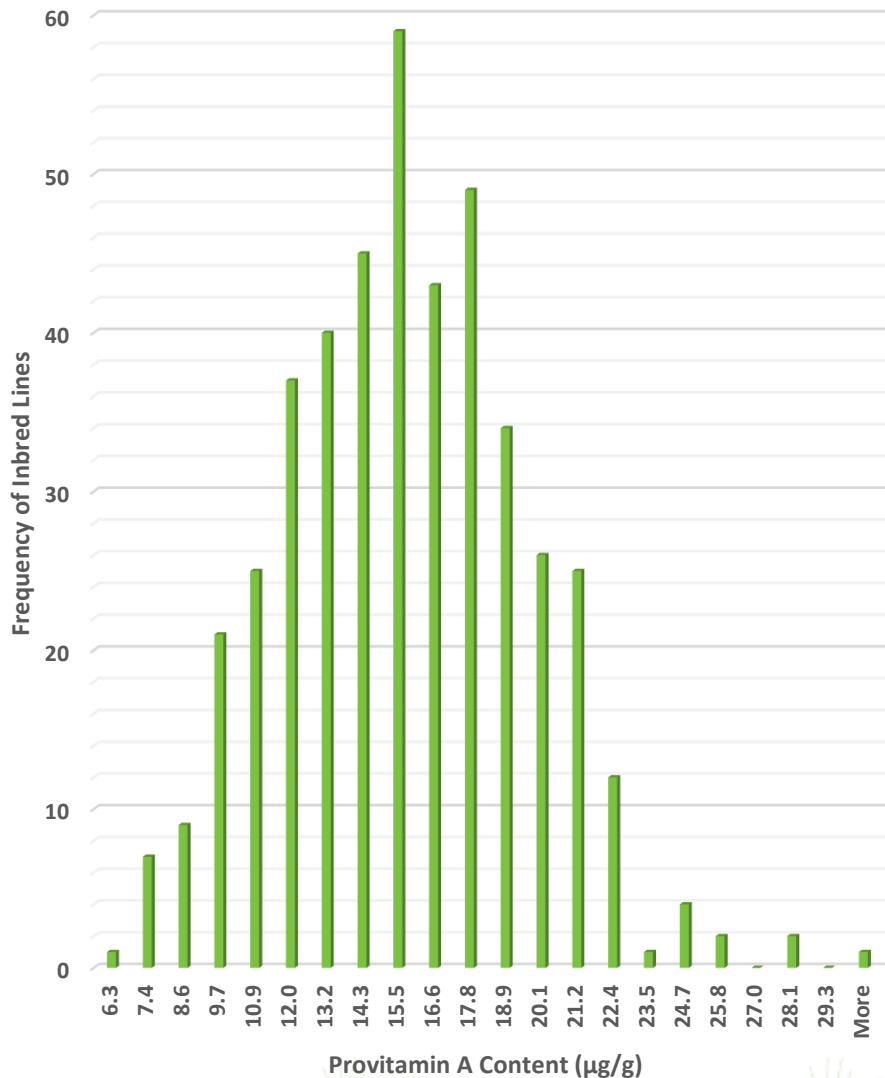
Breeding for Native Genetic Resistance to FAW

- Optimization of screening protocols
- Established 13 screen houses at Kiboko, Kenya
- Screening of ~4000 maize lines and hybrids so far under artificial infestation



Tolerant and susceptible lines under FAW under artificial infestation

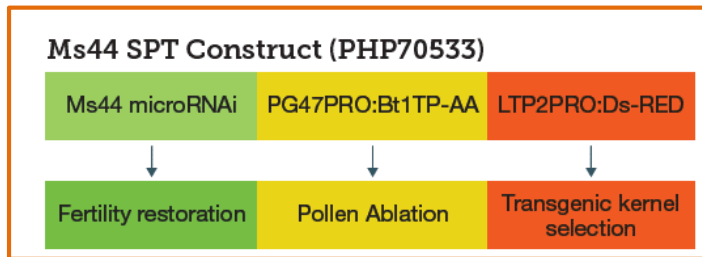
Breeding for Nutritional Maize



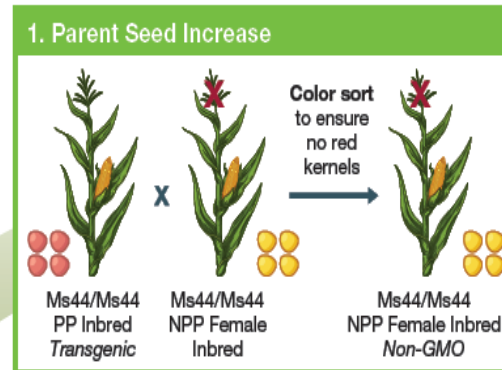
- Provitamin A content of the lines used as males ranges from 6.3 to 30.4 µg/g with an average of 15.2 µg/g.
- 17 hybrids released during 2012-2017, and under commercialisation in the region (Malawi, Tanzania, Zambia, Zimbabwe)



Seed Production Technology for Africa (SPTA)

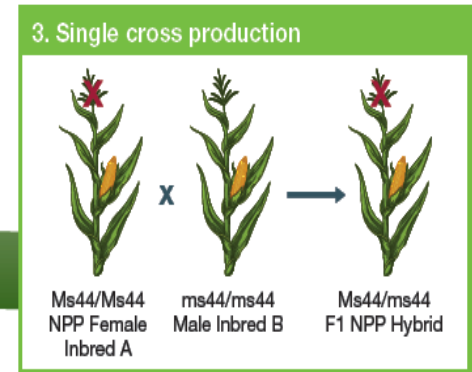
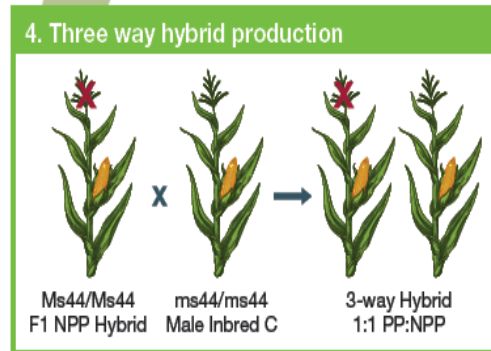


- Benefits:**
- Improved yield under stress conditions (5 – 15%)
 - Improved seed purity of hybrids reaching farmers
 - Production cost savings to seed companies



- Ms44 = dominant mutant
- ms44 = wild type
- NPP = non-pollen producing
- PP = pollen producing

2. Small amounts of non-GMO NPP female seed will be sent (at cost) to licensed seed companies.



Partners



Introgression of Off-PVP US Temperate lines into CIMMYT's Tropical Maize Germplasm

273 Of-PVP lines used

- Crossed with selected tropical adapted lines
- Evaluated in Stage I, II, III, RT
- Hybrids released

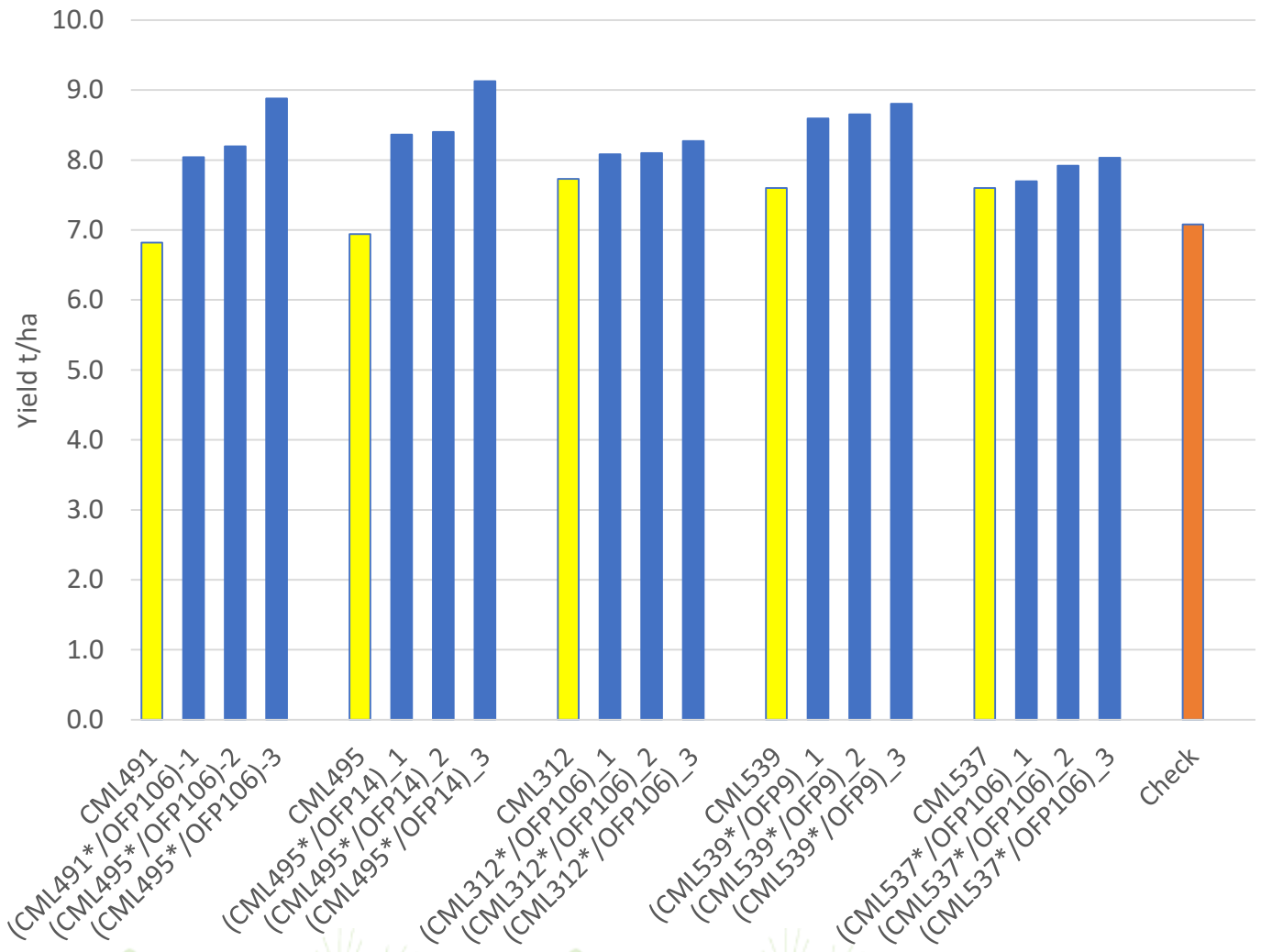


OFF-PVP inbred lines

BC1-S5 temp introgressed tropical inbred lines

Comparison of Off-PVP introgressed and original tropical lines

- 5 tropical adapted lines were crossed with ex-PVP lines
- The original lines together with BC1 fixed lines crossed with 5 testers
- The hybrids were evaluated across seven optimum sites



- # Locations= 7
- Heritability= 0.95



Currently 60% of GMP-Africa maize breeding programs are using DH lines

2018	# of populations	# of DH lines delivered
CIMMYT	137	25290
NARS partners	67	10630
SME seed companies	37	3674

Average number of DH lines produced per population: **156**

- DH lines released as CMLs and used as parents in released commercial hybrids
- MLN tolerant hybrids developed and released

CIMMYT's superior second-generation tropically adapted haploid inducers

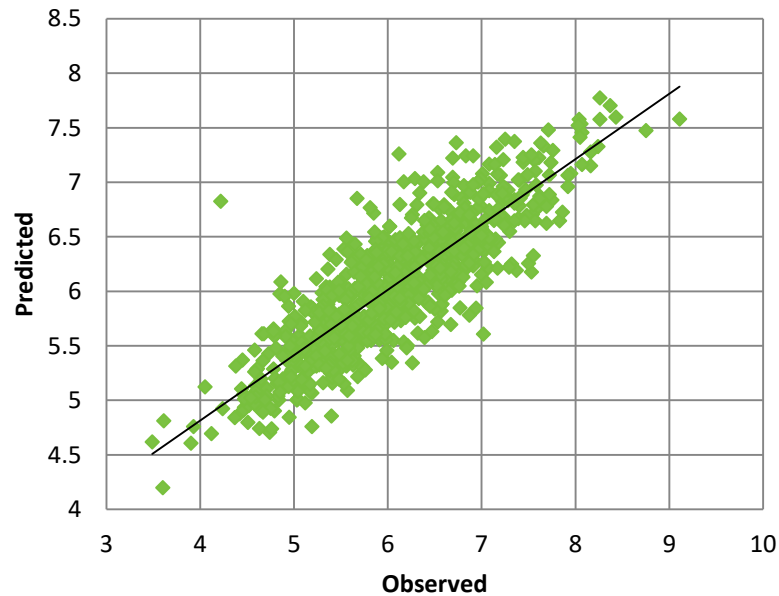


- **CIM2GTAILs with 10-13% HIR** + improved plant vigor, disease resistance, better pollen producibility & seed set, released in August 2017 → reduced DH development costs by 30%.
- CIM2GTAILs shared to 21 Organization globally.

Implementation of GS in stage I trials

- # lines genotyped (Stage I)= 3000
- # lines phenotyped = 853
- # sites= 3 optimum and one managed drought
- The phenotypic data were used to predict the remaining untested lines.

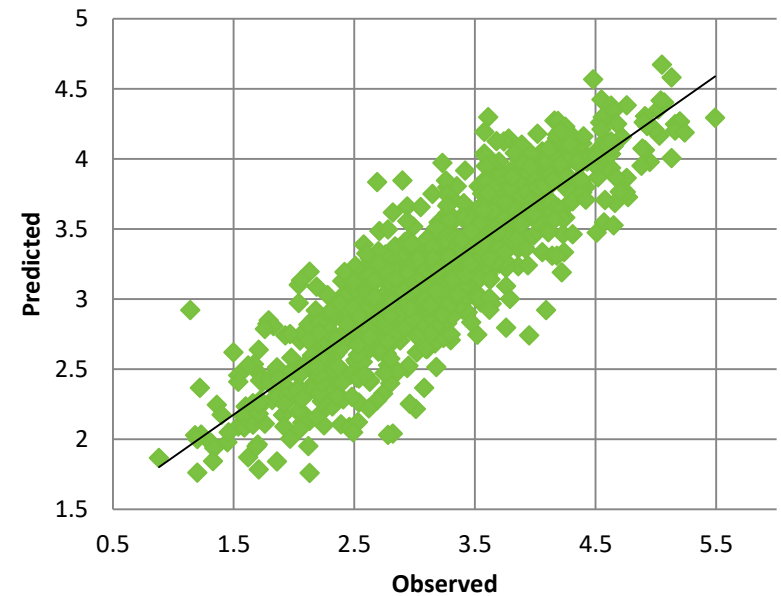
Obs vs Pred -Drought



$R^2 = 0.7249$

◆ Obs vs Pred — Linear (Obs vs Pred)

Obs vs Pred-Optimum

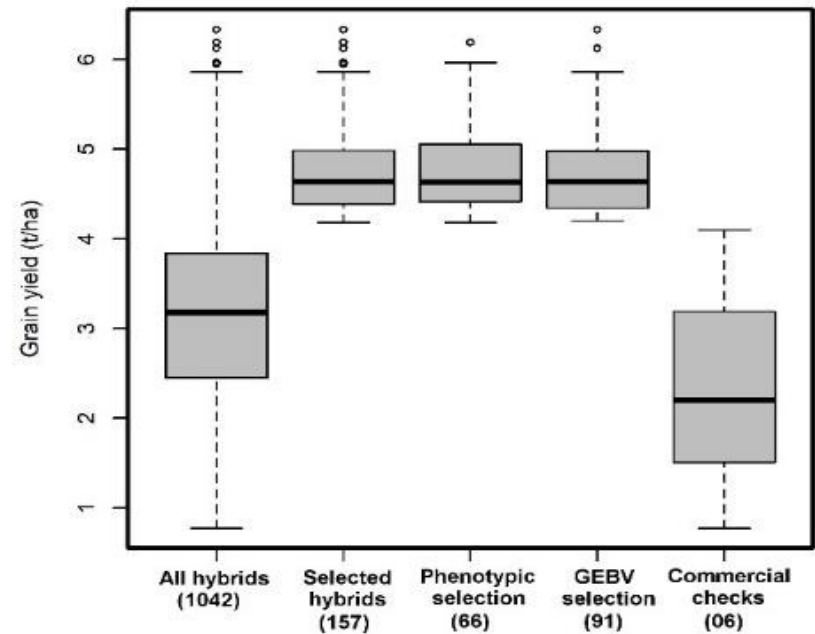
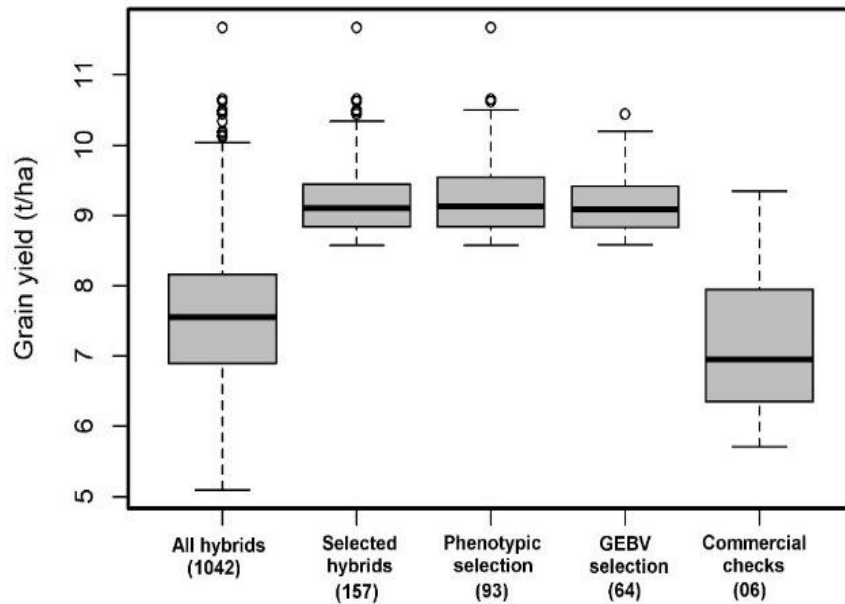


$R^2 = 0.7582$

◆ Obs vs Pred — Linear (Obs vs Pred)

Comparison of hybrids advanced based of PS and GS in stage II trials

Category	# lines	# testers	# of hybrids
All stage II hybrids	347	3	1042
Hybrids advance through phenotype	175	3	526
Hybrids advance through GEBV	172	3	516



Beyene et al. *submitted*

GS reduced the cost by 32% over PS with similar selection gains

Genetic Gain: Intermediate maturity maize across optimum and drought Locations (2008-2017)

Country	Gain kg/ha/year	Reference
Argentina	132	Luque et al., 2006
Eastern and southern Africa	109.4	Masuka et al. 2017a
China	94.7	Ci et al., 2011
Canada	80	Bruulsema et al., 2000
United States	65-75	Duvick, 2005
West Africa	40	Badu-Apraku et al. (2013, 2015)
This study	131	Unpublished

of locations : 37 optimum, 7 drought locations (in Ken, Tan and Uga in 2017 and 2018)

Improved maize distribution within Africa and beyond

Year	# of shipments	# of envelopes	# of institutions	# of countries
2012	209	295,850	72	25
2013	192	643,965	72	25
2014	108	115,498	45	20
2015	119	73,690	48	21
2016	93	70,222	40	17
2017	86	62,996	43	16
2018	61	43,727	21	14
Total	868	1,305,948	341	138



International Maize Improvement Consortium in Africa (IMIC-Africa) initiated in May 2018



- 23 seed companies with annual membership fee
- 11 NARS institutions from in ESA so far as honorary members
- 3 field days were conducted
- Distributed improved lines to partners



Summary

- Incorporated new tools and technologies into product development that delivered the genetic gain 1.75 % per year
- High yielding and stress tolerant hybrids developed and grow by millions of small scale framers in SSA
- Breeding for native FAW genetic resistance initiated
- Shared improved germplasm across the world





**Thank you
for your
interest!**