Doubling Maize Production of India by 2025
Challenges and Opportunities

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Maize has diverse uses and immense opportunities

- Cropping systems and smallholder farmers worldwide depend on maize due to its multi-faceted uses (food, feed, fodder, specialty corn, and industrial uses).

- Flexibility in crop diversification and to fit in crop rotations

- In Asia, maize has recorded the fastest annual growth (around 4 per cent), as compared to other cereals.
Impressive Growth of Maize Sector in India

- India’s maize production rose from 14 million metric tons (MMT) in 2004-05 to 23 MMT in 2013-14, at a CAGR of 5.5%!
- Area under maize cultivation in the period increased at a CAGR of 2.5% from 7.5 M ha in 2004-05 to 9.4 M ha in 2013-14.
- Yield increased at a CAGR of 2.9% from 1.9 t/ha in 2004-05 to 2.5 t/hectare in 2013-14.
- Therefore, India’s maize growth happened not just through area expansion but through hybrid maize adoption.

**Challenge/Opportunity**
Country's maize demand is forecast to grow by 36 per cent in next few years touching 30 MMT in 2017, and double within the next nine years to touch about 44 MMT by 2022.

Hybrid maize seed adoption is around 60 per cent of maize areas; scope for further adoption.
India uniquely poised in world maize exports

Advantage of proximity to large consumption markets

- Large growing consuming markets around
- Locational advantage
Are we seeing sufficient yield trend to double maize production and productivity?

Source: USDA, Directorate of Economics and Statistics, Department of Agriculture and Cooperation
Are we seeing sufficient increase in global maize yields?

www.environmentreports.com/enough-food-for-the-future/
Role of productive SCHs in raising maize yields

Source: USDA,
How can we further double India’s maize production to 44 MMT by 2025?

Requires a strong MISSION with clear goals, institutional responsibilities, and innovative strategies:

• High-yielding, **climate-resilient varieties** that can enhance yields, especially in the *Kharif* and Spring seasons

• **Partnerships** to help reach the unreached with high-quality and affordable seed

• Staying ahead of existing/emerging pests, pathogens and weeds

• Climate-smart **sustainable intensification practices**

• Low-cost farm **mechanization** options

• **Nutrient management** and decision support tools

• Input and output **markets**

• Skilled human resources
Declining Public Share of R&D Funding

Source: Pardey et al. (2015, forthcoming)
Several excellent single-cross hybrids developed and released under AICMIP!

- The multinationals’ focus has been on favourable markets and growing season (Rabi) in India – important but not sufficient!

- We have not yet succeeded in catalysing adoption of high-yielding climate-resilient maize hybrids suitable for Kharif season for quantum increases in maize yields.

- The public sector share in the overall commercial maize seed sector in India is disproportionally low, as compared to countries like China, Thailand and Vietnam.
Some excellent single-cross hybrids developed under AICMIP!

**Vivek Maize Hybrid 45** developed by VPKAS (CML470 is the male parent) showing excellent performance in Uttarakhand
Water Deficit + Heat Stress

Up to 23% of Asia’s maize crop could be lost due to higher temperatures by 2050.

Spring Maize Environments and Heat Stress

Maize grain yield (t/ha) vs. Night Temperature

- The graph shows a negative correlation between night temperature and maize grain yield.
- As night temperatures increase, maize grain yield decreases.

[Graph showing data points and a trend line.]
Heat Stress Phenotyping Network in South Asia

- GIS-based characterization
- 23 heat stress phenotyping sites in South Asia
- HTMA Project partners including CIMMYT, Purdue, Pioneer, NARS and SMEs in Bangladesh, India, Nepal, Pakistan and Bhutan

PH Zaidi (CIMMYT-India)
Promising CIMMYT-Asia hybrids with heat tolerance

Heat tolerant commercial hybrids currently marketed in Asia

Green bars = commercial checks
Red bar = worst entry

Grain yield (t/ha) under heat stress

Heat tolerant commercial hybrids currently marketed in Asia
Heat Tolerant Maize for South Asia

• 11 heat stress tolerant maize hybrids allocated recently to public and private sector partners in India, Bangladesh, Nepal and Pakistan
• 7 more hybrids in pipeline for allocation to partners in S Asia
Need to significantly increase genetic gains under stress-prone environments
Shortening, widening and improving the breeding funnel...

Source: Based on Cooper et al. (2014)
Maize DH Development Service through a Centralized Platform

DH development service to NARS and SME seed company partners, besides CIMMYT and IITA

~60,000 DH lines developed from 235 source populations in the first year of operations

Proposal under consideration by DBT for establishing a similar DH platform in India
Sherett Chase’s Pioneering Efforts

First to develop maize DH lines and commercially used hybrids based on DH lines

- First haploid to doubled haploid in sweet corn (Golden Cross Bantam)
- First substantial confirmation of different rates of parthenogenesis among female parents influenced by the male parent
- First to use ‘embryo markers’ for dry seed haploid selection (Pu, etc.)
- First DH lines in successful commercial hybrids (example: DeKalb 640)
- First ‘second-generation’ DH lines in commercial hybrid (H2386 and H2389, both ex H73xH225)
‘Stock 6’ and Genetic Selection Technique

• Identification of a haploid inducer stock, with relatively higher haploid induction rate (3.23%) as compared to spontaneous induction rate (Coe, 1959).

• Utilizing anthocyanin color marker expression in endosperm and embryo for easy identification of haploids (Coe and Sarkar, 1964).

• Genetic analysis of the origin of maternal haploids in maize (Sarkar and Coe, 1966).
### DH Lines in Improved Maize Hybrids for SSA

<table>
<thead>
<tr>
<th>Year</th>
<th># DH Lines</th>
<th>Source Pops</th>
</tr>
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<tbody>
<tr>
<td>2010-2012</td>
<td>5089</td>
<td>106</td>
</tr>
<tr>
<td>2013</td>
<td>1456</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>355</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>5105</td>
<td>47</td>
</tr>
<tr>
<td>2014</td>
<td>5,573</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>13,390</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>706</td>
<td>11</td>
</tr>
<tr>
<td>2015</td>
<td>60,000</td>
<td>235</td>
</tr>
<tr>
<td>Total</td>
<td>91,674</td>
<td>545</td>
</tr>
</tbody>
</table>

36 of the 40 CIMMYT hybrids released through WEMA Project by CIMMYT in Kenya, Tanzania and Uganda are based on DH lines!
16 new CMLs (CML562-577) released in Sept 2015
5 DH lines among these (CML566-570), for the first time!
New Drought Tolerant Single-Cross Testers
to replace some of our old testers

CKDHL0277/CML442

CKDHL0165/CKDHL0323
High-throughput Field-based Phenotyping

Aerial remote sensing

CIMMYT, in partnership with CSIC (Spain), University of Barcelona (Spain), and Crop Breeding Institute (Zimbabwe)
More Accurate Selection

<table>
<thead>
<tr>
<th>Trial</th>
<th>NDVI (SkyWalker)</th>
<th>NDVI (SkyWalker) + Plant Height</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0.98</td>
<td>1.06</td>
</tr>
<tr>
<td>2</td>
<td>1.06</td>
<td>1.11</td>
</tr>
<tr>
<td>3</td>
<td>0.99</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Zaman- Allah et al. 2015
Production Markers for High Value Traits

**Discovery**
- Heat
- *Striga*

**Validation**
- GLS
- TLB
- Drought
- NUE
- Soil acidity

**Deployment**
- Provitamin A
- MSV
- MLN
- Haploid Induction Rate
Making yield gains in the farmers’ fields requires much stronger and focused public-private partnerships.
Translating genetic gains to yield gains under farmers’ conditions...

In the past:
Number of improved crop varieties generated

Time to the market of competitive products = Time to impact
- Rate of turnover of improved varieties
- Identifying easy-to-produce hybrids
- Stimulating demand
- Rapid seed scale-up and delivery through effective partnerships

Today:
Demonstrated impact in farmers’ fields
Strengthening Interface between Breeding, Seed Systems and Socioeconomics teams

- Product preferences
- Trait preferences
- Mainstreaming gender
- Crop modeling for adaptation to climate change

- Seed production characterization
- Hybrid productivity

- Assessing market opportunities
- Stimulating demand
- Economics of seed production
- Policy support

Product Delivery Team

Breeding to Product Delivery

Product Development Team

Socio-economics Team
CIMMYT Maize Program works with >175 seed companies across Africa, Asia and Latin America!

>52,000 tons of drought-tolerant maize seed produced and delivered by seed company partners in 13 African countries in 2014, reaching 5 million households
Improved Maize Seed to the Market
Our Model for Partnership with Seed Companies

Equality ≠ Equity

Large Medium Small Large Medium Small
Scaling-up and delivering improved DT maize seed in SSA

Estimates of drought tolerant maize seed production, potential area covered, households and people benefiting, 2014

<table>
<thead>
<tr>
<th>Country</th>
<th>Volume (in MT)</th>
<th>Area (in ha)</th>
<th>Beneficiaries</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Households</td>
<td>People</td>
<td></td>
</tr>
<tr>
<td>Angola</td>
<td>1,500</td>
<td>60,000</td>
<td>150,000</td>
<td>996,000</td>
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<tr>
<td>Benin</td>
<td>1,787</td>
<td>71,468</td>
<td>178,670</td>
<td>2,322,710</td>
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<tr>
<td>Ethiopia</td>
<td>5,464</td>
<td>218,571</td>
<td>546,427</td>
<td>4,152,845</td>
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<tr>
<td>Ghana</td>
<td>2,444</td>
<td>97,760</td>
<td>244,400</td>
<td>2,688,400</td>
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<tr>
<td>Kenya</td>
<td>5,065</td>
<td>202,600</td>
<td>506,500</td>
<td>3,393,550</td>
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<tr>
<td>Malawi</td>
<td>5,400</td>
<td>216,000</td>
<td>540,000</td>
<td>2,808,000</td>
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<tr>
<td>Mali</td>
<td>1,152</td>
<td>46,074</td>
<td>115,185</td>
<td>182,430</td>
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</tr>
<tr>
<td>Mozambique</td>
<td>1,500</td>
<td>60,000</td>
<td>150,000</td>
<td>930,000</td>
<td></td>
</tr>
<tr>
<td>Nigeria</td>
<td>14,291</td>
<td>571,636</td>
<td>1,429,089</td>
<td>15,719,979</td>
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<tr>
<td>Tanzania</td>
<td>3,578</td>
<td>143,112</td>
<td>357,780</td>
<td>2,218,236</td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>3,192</td>
<td>127,668</td>
<td>319,170</td>
<td>2,329,941</td>
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</tr>
<tr>
<td>Zambia</td>
<td>2,000</td>
<td>80,000</td>
<td>200,000</td>
<td>1,280,000</td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>5,545</td>
<td>221,800</td>
<td>554,500</td>
<td>2,606,150</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>52,917</strong></td>
<td><strong>2,116,688</strong></td>
<td><strong>5,291,721</strong></td>
<td><strong>41,628,241</strong></td>
<td></td>
</tr>
</tbody>
</table>

1 MT enough for 40 ha; each family plants not more than 10 kg.
Doubling Maize Productivity in Mexico through MasAgro Seed Companies and Producers in the Partnership

Targeted involvement of 55 seed companies in Mexico as partners under MasAgro-Maize Program
Doubling Maize Productivity in Mexico through MasAgro Impact at Municipality level through Combination Products
Doubling Maize Productivity in Mexico through MasAgro
Involving Producers in the Partnership

More than 150,000 producers linked to the MasAgro Program and its aligned projects.

Additional income estimated at US$ 105 million per year to the country
IMIC-Asia: Expanded collaborative testing network

- AICRP-Maize, represented by IIMR, is a member of this consortium, besides 45 seed companies
- **Trait focus**: drought tolerance, heat tolerance, disease resistance, temperate introgressions and high yield potential
- 798 Inbred lines demonstrated in 2014 field day; 692 lines selected by 54 members, including 23 AICRP partners
- ~3300 seed samples dispatched to AICMIP partners
We need much more than improved varieties to sustainably enhance maize production and improve farmers’ livelihoods and income.
Sustainable Intensification and enhanced national maize yields
= Improved Genetics + Improved Agronomy + Enabling Policies and Institutions
Technologies that can make a difference...

Nutrient Management Tool for Smallholder Farmers Wins Award

Tips to Increase Maize Yields in Plateau of Odisha

July, 2015

MADE IN BANGLADESH:
SCALE-APPROPRIATE MACHINERY FOR AGRICULTURAL RESOURCE CONSERVATION

Timothy L. King, Phil Santiago, James Valley, Andrew J. McDonald, Scott Justice, Saral Hussein and Mahesh K. Tehotia
Technical Drawings: Santiago Samuel Valea

Conservation Agriculture: Innovation for a significant change in Mexican soil

Experimental Platforms

Conservation Agriculture: Innovation for a significant change in Mexican soil

How do Regional Hubs work?

1. Experiment Station
2. Demonstration Farm
3. Farmers’ Field School
4. Smallholder Farmers

Conservation Agriculture Benefits

50% reduction in average reduction in farm work

70% reduction in farm work

CGIAR Research Program on Maize
Sustainable Intensification of maize-based farming systems

Conservation Agriculture + Diversification + Precision Agriculture =

11% Yield increase
46% Energy decrease
71% Irrigation decrease
32% Profitability increase
MISSION 2025 for Doubling Maize Production in India

Policy and institutional innovations are just as important as technological innovations

- **INTEGRATE** – research, extension, education, training

- **CONNECT** – farmers, producers, entrepreneurs, consumers

- **STRENGTHEN** – the entire maize innovation system
Policies are certainly important. But more important is **Policy Practice**

- Addressing *formulation + implementation* simultaneously
- Good policy practice – *institutional capacity* and effectiveness to coordinate, advocate, promulgate, implement, follow-up, review and continually update
Thanks!