Maize and Wheat Science for Improved Livelihoods

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International Maize and Wheat Improvement Center (CIMMYT)
CIMMYT

Mission
Wheat and maize science for improved livelihoods
The Office of Special Studies (OSS) is created

OSS develops high-yield, disease-resistant, semi-dwarf wheat and shuttle breeding

Norman Borlaug is awarded the Nobel Peace Prize

The Green Revolution in India and Pakistan

CIMMYT is officially founded

The Wellhausen-Anderson Plant Genetic Resources Center opens

CIMMYT scientists win the World Food Prize

CIMMYT responds to the food price crisis and expands globally
BIG Family with Diversity of Culture and Scientific Skills
Major Achievements

$2 billion 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.
Wheat Helps Feed the World

- Most widely cultivated cereal grain
- 20% of all calories and protein

2.5 billion people in 89 countries = < $2 a day

60% more wheat than today... the amount the world will need to grow to meet consumer demand by 2050.
Maize Helps Feed the World

- Preferred staple food to 900 million people living on less than $2 a day.

- Maize provides 15-56% of total calorie intake in sub-Saharan Africa, Latin America and Asia.

- 184 million hectares worldwide.
CIMMYT is Part of the CGIAR
The Germplasm Bank

- Wellhausen-Anderson Plant Genetic Resources Center, established in September 1996 with funding from the government of Japan.
- ISO-certified.
- 28,000 entires of maize and 138,000 of wheat.
- CIMMYT seed is made freely available: 500,000 packets of seed are sent to more than 600 partners each year.
Global Seed Distribution Network
CGIAR: Working Within Agri-food systems

AGRI-FOOD SYSTEM PROGRAMS

- Dryland cereals and legumes agri-food 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

GLOBAL INTEGRATING PROGRAMS

- Managing and Sustaining Crop Collections (Genebanks)
- Genetic Gains

GLOBAL PROGRAMS

- Agriculture for Nutrition and Health (A4NH)
- Climate Change, Agriculture and Food Security (CCAFS)
- Water, Land and Ecosystems (WLE)
- Policies, Institutions and Markets (PIM)
WHEAT Agri-Food Systems

Interlinked WHEAT Flagship Projects in Phase II

FP1: Enhancing WHEAT’s R4D strategy for impact
FP2: Novel diversity & tools for improving genetic gains and breeding efficiency
FP3: Better varieties reach farmers faster
FP4: Sustainable intensification of wheat-based farming systems

Cross-cutting CoA: Capacity Development
MAIZE Agri-Food Systems

FP1: Enhancing MAIZE’s R4D strategy for impact

FP2: Novel diversity and tools to improve genetic gains

FP3: Stress-tolerant and nutritious maize

FP4: Sustainable intensification of maize-based systems for smallholder farmers

FP5: Adding value for maize producers, processors, and consumers

System level outcomes:
1. Reduced Poverty
2. Improved food & nutritional security for health
3. Improved natural resource systems & ecosystem services
Climate Change, Agriculture and Food Security (CCAFS)

<table>
<thead>
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<th>FP1</th>
<th>Priorities and policies for CSA</th>
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<td>FP2</td>
<td>Climate-smart technologies and practices</td>
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<td>FP3</td>
<td>Low emissions development</td>
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<td>FP4</td>
<td>Climate services and safety nets</td>
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Borlaug Institute for South Asia (BISA): A joint initiative of CIMMYT and ICAR (Govt of India)

To contribute to sustainable food security, poverty reduction and economic development in South Asia by facilitating collaboration between cutting-edge national, regional and international organizations in the area of agricultural research.
Scientific Excellence

Genetic Resources
- Genetic Resources & Bioinformatics
- Genetic resources, informatics, biometrics, seed health and distribution

Maize and Wheat Programs
- Improved Germplasm
- Breeding, phenotyping, seed systems

Sustainable intensification
- Sustainable Intensification
- Agronomy, soil sciences, precision agriculture, mechanization

Socioeconomics
- Foresight, Targeting & Impact Assessment
- Socioeconomics & geographic information systems
Impact through Partnerships

- Industry
- ARIs
- NGOs
- Development Organizations
- Donors
- CGIAR Centers
- NARS
Capacity Building

50,000 days training given each year.

Technical courses
Farmers’ days
Workshops
PhD/MSc students

More than 10,000 scientific and professional alumni around the world.
Global Warming in South Asia: 800 Million at Risk

By SOMINI SENGUPTA and NADJA POPOVICH | JUNE 28, 2018

Map showing
- Moderate emissions scenario: South Asia warms about 1.6°C by 2050
- High emissions scenario: South Asia warms about 2.2°C by 2050

Decrease in living standards:
- None
- Low
- Moderate
- High
- No data
Our Research for Development Focus in South Asia

In addition to enhancement and exchange of high yielding stress tolerant germplasm of wheat and maize across nationals programs of wheat and maize in India, CIMMYT in close collaboration with NARS work at ground on following thematic research areas:

• Abiotic stresses
• Biotic stresses
• G x E x M
• Sustainable intensification
• Climate Smart Agriculture
• Smart farm mechanization
• Precision agronomy
• Farming systems modelling, typologies and targeting
• Bio-fortification, quality
• Value chain, socio-economic and impacts
• Gender and youth in agriculture
• Business models and innovation systems
We are intensively working for addressing the agricultural challenges in diversity of farming systems.
Few Specific Examples

1. Air pollution
2. Climate change/climate smart agriculture
3. Water
4. Conservation Agriculture
5. Scale appropriate mechanization
6. Precision agronomy and digital agriculture
7. Farming systems design and targeting
8. Technology led business models
9. Evidence based policy guidance
Burning issues of paddy residue management in north-west states of India

Shiv Kumar Lohan, H.S. Jat, Arvind Kumar Yadav, H.S. Sidhu, M.L. Jat, Madhu Choudhary, Jyotsna Kiran Peter, P.C. Sharma

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Delhi’s Government Declares A Public Health Emergency As Air Pollution Chokes The City

Mumbai: Air pollution contributed to a total of 80,665 premature deaths of adults over 30 years in Mumbai and Delhi in 2015, a two-fold jump from 1995, according to a new study at the Indian Institute of Technology, Bombay.

In economic terms, air pollution cost the two cities ₹10.66 billion (approximately Rs 70,000 crore) in 2015, or about 0.71% of the country’s gross domestic product. The study has said the impact on health and productivity as a result of exposure to pollution and the consequent burden of respiratory ailments rose with every passing decade.

Researchers calculated using data on PM 10 (fine particulate matter measuring 10 microns), population and death rates.

With its higher pollution levels, Delhi recorded more premature deaths due to ingestion of PM10 from vehicle exhaust, construction dust and other industrial processes. Casualties went up from 19,716 in 1995 to 48,651 in 2015.

In Mumbai, the comparative figure rose from 19,289 to 32,014 in 20 years.

>10bn pollution cost, P 18
Rice Residue Burning is a Major Concern in NW India

- Rice residue burning in NW India: 23 mt
- Loss of $>9$ mt C (34 mt CO2-eq) per year
- Loss of $\sim0.15$ mt N (US$ 31 million)
- Water, health

Each dot indicates active fire detected by satellite
Development and evaluation of the Turbo Happy Seeder for sowing wheat into heavy rice residues in NW India

H.S. Sidhu, Manpreet Singh, Yadvinder Singh, J. Blackwell, Shiv Kumar Lohan, E. Humphreys, M.L. Jat, Vicky Singh, Sarbjeet Singh

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fDasmesh Mechanical Works Pvt. Ltd, Amargarh, Punjab, 148022, India
Evidence Base From Long-term Research on Sustainable Intensification of Cereal Based Systems in NW-IGP

- Improved productivity and soil health (Productivity 1-1.5 t/ha/yr, SOC 2-4 t/ha/yr)
- Reduced weather risks (High adaptability and Low CV in crop yield)
- Reduce Chemical load (20-25 kg N/ha, Less herbicide)
- More crop per drop: Save irrigation water
  - Rice-wheat-mungbean: 60-70 ha-cm/yr
  - Maize-wheat-mungbean: 150-175 ha-cm/yr
- More profit: Lower costs and higher yields (Profit 20000-25000/ha/yr)
- Lower GHGs emission (~1.5 t CO2-eq/ha/yr)
Unsustainable extraction of groundwater from world’s major aquifers: NASA GRACE satellite mission

Laser Assisted Precision Land Leveling: Impact at Scale

Introduced in India during 2000-01 (RWC/CIMMYT-IRRI, ICAR)

- Adoption: ~5 million ha in India
- Direct employment generation: 350 person days/unit/yr
- Yield gains in RW system (5 mha, 0.5 t ha-1 yr-1) - >2 mt yr-1
- Other possible benefits - GHG mitigation, savings in subsidy bill etc

At current level (>35000 units):
- 10.5 million person days/yr

Indirect employment: manufacturing, transport, services

Electricity saving for irrigation in RW systems of IGP

Water saving in RW system (5 mha, 18 ha-cm ha-1 yr-1) = 10 km3 yr-1

Source: Jat et al, 2006; 2009a,b; 2011; 2015; Aryal et al, 2015
Portfolio: Layering precision water & nutrient management in CA based rice-wheat system

- Layering sub Surface drip (SSD) irrigation system in CA based RW system produced (over conventional till rice-wheat)-
  - ~1.0 t/ha/year higher RW yield
  - With ~70 cm less irrigation water
  - Double irrigation water productivity
  - 38% increase in PFP-N
  - 7.5 % lower environmental footprints
Addressing Food-Energy-Water (FEW) Nexus (Layering CA with Fertigation, Solar energy)

<table>
<thead>
<tr>
<th>System magt</th>
<th>Irrigation method and energy source</th>
<th>System yield (t ha⁻¹ yr⁻¹)</th>
<th>System net income (USD ha⁻¹ yr⁻¹)</th>
<th>System water use (cm ha⁻¹ yr⁻¹)</th>
<th>System energy use (kWh ha⁻¹ yr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZTDSR-ZTW</td>
<td>SSD with solar power</td>
<td>12.33c</td>
<td>2094</td>
<td>96d</td>
<td>3663</td>
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<tr>
<td>ZTDSR-ZTW</td>
<td>Flood</td>
<td>11.94c</td>
<td>2000</td>
<td>167e</td>
<td>6151</td>
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<tr>
<td>TPR-CTW</td>
<td>Flood</td>
<td>12.18c</td>
<td>1909</td>
<td>181f</td>
<td>6686</td>
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<tr>
<td>PBM-PBW</td>
<td>SSD with solar power</td>
<td>13.67a</td>
<td>2357</td>
<td>29a</td>
<td>1249</td>
</tr>
<tr>
<td>PBM-PBW</td>
<td>Furrow irrigation</td>
<td>13.24ab</td>
<td>2318</td>
<td>49b</td>
<td>1714</td>
</tr>
<tr>
<td>CTM-CTW</td>
<td>Flood</td>
<td>12.56bc</td>
<td>2087</td>
<td>59c</td>
<td>2027</td>
</tr>
</tbody>
</table>

- CA + micro-irrigation within RW system: same yields with 85 cm /ha/yr less water, half energy use and USD 185/ha/yr higher income
- CA + micro irrigation in MW system: 1.5 t/ha/yr more yield, 152 cm water saving with one quarter energy use and USD 450 /ha/yr more profit compared to conventional RW system in NW India
Climate-Smart Agriculture?

Consortium of Practices and Policies

- Adaptation
- Food Security
- Mitigation

Outputs:
- Productivity
- Returns
- Efficiency
- Emissions
- Resilience

CIMMYT
A global analysis of alternative tillage and crop establishment practices for economically and environmentally efficient rice production

Debasish Chakraborty1, Jagdish Kumar Ladha2, Dharamvir Singh Rana3, Mangi Lal Jat1, Mahesh Kumar Gathala6, Sudhir Yadav2, Adusumilli Narayana Rao5, Mugadeli S. Ramesha2 & Anitha Raman6

Alternative tillage and rice establishment options should aim at less water and labor to produce similar or improved yields compared with traditional puddled-transplanted rice cultivation. The relative performance of these approaches in terms of yield, water use, and economic inputs across rice
CA in Maize Systems: Adapting Climate Risks (200+ mm in 3 days in end of June 2017) in Haryana, India

5.57 t/ha

4.37 t/ha
Identifying cost-effective opportunities for climate change mitigation in India

- All options are climate smart
- Technical Mitigation potential = 86 MtCO$_2$e/year
- 80% of mitigation potential achieved via cost saving options
Evidence base from Climate Smart Villages

Participatory approaches for developing portfolios of climate smart practice helps in showcasing the multiple benefits in real farming conditions with better replicability of outputs.

Pilots of CSVs across South Asia
Minimum mechanical soil disturbance (the minimum soil disturbance necessary to sow the seed)

Permanent organic soil cover (retention of adequate levels of crop residues on the soil surface)

Diversified crop rotations including cover crops (to help moderate possible weed, disease and pest problems)

Conservation Agriculture is based on three principles applied simultaneously (FAO, 2009)
Sustainable intensification through scale appropriate mechanization
Sustainable Intensification in intensive systems
Digital soil mapping: combines legacy point data (e.g. from AICRP) with remote sensing co-variates and advanced geo-statistics + machine learning to predict soil properties at scale.

1. New collaborations in Bihar, Odisha, and Andhra Pradesh endeavors to power decision-making and agro-advisory at scale by efficiently developing reliable predictions of soil properties at scale.

2. INSET: MAPPING SOIL CONCENTRATIONS OF ZINC IN ANDHRA PRADESH

3. Data aggregation + cleaning

Uncertainty assessment to guide efficient sampling

Predictive mapping with remote sensing + machine learning
Sensor technologies and decision tools for smallholder farmers
One Size Doesn’t Fit All—Technology Targeting is a Must
Farm household typologies and food security: An ex-ante assessment from Eastern India

Climate smart agriculture, farm household typologies and food security
An ex-ante assessment from Eastern India

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a. Begusarai, b. Samastipur, c. Nawada, d. across distts
Exploring windows of opportunity

Current practices

New practices

Recombine

Objectives

Select

Constraints
Targeting with Clarity of Objectives

Ecosystem Services

Original farm configuration

Farm profitability

Legend:
- Housing
- Intensive grassland
- Extensive grassland
- Maize
- Wheat
- Woodland

Original farm configuration
Challenges require comprehensive system-level approaches & joined-up policies

Farming system approach:
- Farmer Income,
- Livelihoods,
- Nutrition,
- Soil Health,
- Climate Resilience,
- Environmental Foot Prints

Synergies and Tradeoffs
Technology led business models for scaling

Enhancing the role of private sector in scaling agriculture technologies
Thank you for your interest!

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