Rice Science to Ensure Global Nutrition and Food Security

Speaker

Robert Zeigler, Director of the International Rice Research Institute (IRRI)

September 24, 2014
Upcoming Agrilinks Events:

- Seminar | October 9th | Emergency Seed Systems

- Ag Sector Council | October 22nd | From Smallholders to Shareholders: A Guide to Optimizing Private Sector Partnerships for Smallholder Impact
Saharah Moon Chapotin
USAID Bureau for Food Security

Saharah Moon Chapotin is Division Chief for Agricultural Research at USAID. She joined USAID in 2006 as a Biotechnology Advisor, managing international partnerships to promote the adoption of conservation agriculture practices in South Asia, and develop bioengineered crops for small-holder farmers. Prior to working at USAID, Chapotin worked at the Biosafety Institute for Genetically Modified Agricultural Products at Iowa State University. Chapotin holds a B.S. in Biology from Stanford University, a Ph.D. in Plant Physiology from Harvard University, and has completed the AAAS Science and Technology Policy Fellowship Program.
Robert Zeigler
International Rice Research Institute

Robert "Bob" Zeigler is an internationally respected plant pathologist with more than 30 years of experience in agricultural research in the developing world. He became Director General of the International Rice Research Institute (IRRI) in 2005. IRRI headquarters, with more than 1,000 scientists and support staff, is in the Philippines, with offices in 15 countries and activities in more than 25 others. IRRI focuses on sustaining, understanding, and using the genetic diversity of rice to improve rice productivity and the livelihood of rice farmers and consumers.
"Rice Science: A Powerful Weapon in the War Against Hunger and Poverty"

R. S. Zeigler
Director General
International Rice Research Institute
INTERNATIONAL RICE RESEARCH INSTITUTE
Los Baños, Philippines

Mission:

- Reduce poverty and hunger,
- Improve the health of rice farmers and consumers,
- Ensure environmental sustainability
- Through research, partnerships

Home of the Green Revolution
Established 1960

A case study in applying research to development
Consultative Group on International Agricultural Research (CGIAR)

Global Rice Science Partnership (GRiSP)
What is rice?

Perhaps the oldest domesticated crop
  • Tremendously diverse

More than just food
  • Though it is the primary staple for billions (~ 50% of world & ~ 75% of poor)

Flourishes in an exceedingly wet monsoon environment
  • Impossible for other staples
Rice is typically grown by small family farm enterprises (<2 ha)...saved seed

Animal draft power

Reliance on human labor...

For how long?
The “Rice Theory”

“...proposes that a history of farming rice makes cultures more interdependent, whereas farming wheat makes cultures more independent, and these agricultural legacies continue to affect people in the modern world”

Dr. Thomas Talhelm, University of Virginia

“...you do not need to farm rice yourself to inherit the culture.”
The Green Revolution in Asia

1960s
- yields ~1.5 t per ha
- widespread famines predicted

Today
- yields ~4 t per ha
- economic growth

IR8 (semi-dwarf) launched the Green Revolution and saved millions from starvation

Science doing what people said could never be done

Annual rate of yield increase:
52.4 kg grain/ha
($R^2=0.982$)

World rice yield (t/ha)
If we want to do something about poverty, it is clear that we must invest in rice.
The face of poverty
The consequences of poverty...
Hunger and malnutrition
Yu Shangping with his nephew Li Ande and sister Yu Shangzhen in Chala, Yunnan Prov. China
Global per capita rice consumption has remained stable for the last ~25 yrs.
Global rice production increases needed to meet demand by 2035

Additional rice needed: 114 million tons by 2035

2010 global rice production

Asia  Africa  Americas  Rest of world
To Make Matters Worse: Climate Change Effects on Rice Production Hit Asia Hard
Where Will the World’s Rice Come From?

• Ideally from increasing productivity on existing rice lands, mostly in Asia, (in 20+ years increasingly from Africa)

• BUT, in Asia:
  • Land is moving out of rice
  • Labor is moving out of rice
  • Water is moving out of rice

• Major changes in production practices and increases in efficiency Just to stay where we are

• If Asia does not produce sufficient rice, the world will be food insecure
To Meet Tomorrow's Food Needs and Address Challenges of Nutrition and Poverty Under a Changing Climate

A Second Science–based Green Revolution is Needed
Science–based?

• Tap the revolutions in genetics, molecular biology and plant physiology
• Link soils biology and chemistry to better understand and manipulate sustainable nutrient supply
• Exploit the explosion of computation capacity and remote sensing to model systems and link process at scales from the cellular through ecosystems and regions
• Proactively link the political and social dimensions of agriculture to technology development
Cannot Overestimate Central Role of Genetic Resources for Coming Generations

IRRI holds in trust the world’s largest collection of rice varieties...> 110,000 accessions

Less than 5% has been used in breeding programs, but...

Completed full DNA sequencing of 3000 lines in 2014
Conserved Germplasm
Breeding Lines
Specialized Genetic Stocks

Genetic Resources and Diversity as Foundation

Gene Function

phenotype
genotype

Durable disease-pest resistance
Abiotic stress tolerance
Dissemination
Problem soils

Future challenges
Current problems

Phenotype-genotype association

conservation
Sequence and Evaluate ~10,000 Rice Accessions

- Developing high-density genotyping Affy arrays with 1 M SNPs
- Includes newly discovered SNPs from >150 genomes and from other projects
- Initial genotype 3000 rice lines spanning range of diversity
- [http://www.ricesnp.org](http://www.ricesnp.org)
- Partners include Cornell, USDA, AfricaRice, CIRAD, Bayer CropSciences, Syngenta, CIAT, BGI – CAAS, USAID Linkage

- Coordinated collaboration in bioinformatics & data management: adhere to highest standards of public access
Making rice climate-ready

- drought
- salinity
- submergence
- heat
Mega-river deltas of Asia

50% of rice production growth in last 25 years came from delta countries
Breeding for submergence tolerance

- Large areas of rain-fed lowland rice have short-term submergence (eastern India to SE Asia); > 10 m ha

- Even favorable areas have short-term flooding problems in some years

- Flood tolerance identified in a traditional Indian variety FR 13A in 1978
  - Poor field performance and grain quality
New Sub1 lines after 17 days submergence in the field at IRRI
Sub1 varieties: help poor farmers cope with frequent flooding

Major support from Japan USAID, B&MGF, GOI enables us to reach >5M farmers by 2015...millions more over the next few years

Released in Bangladesh, India and Philippines 2009... Nepal in February 2011

Mr. Asha Ram Pal
Village Palia Goa,
District Faizabad,
Uttar Pradesh
Stress tolerant rice – accelerate adoption by farmers through private sector engagement

2013: Sub1 Varieties reached ~4 m farmers on ~1.7 m ha
This study “... indicates that scheduled castes are likely to be a major beneficiary from the spread of Swarna-Sub1 in India.”
Variation in Rainfall = Risk of Drought

Weighted Anomaly of Standardized Precipitation (WASP) 1980-2000 [deciles]

1 Dot = 50,000ha Rainfed rice
Drought tolerant varieties

• Drought tolerant varieties across S Asia 2009-14
• Yield advantage of 0.8-1.2 t/ha under moderate to severe drought, but with no penalty under non-stress conditions

Sahbhagi dhan in India

Tarharra 1 in Nepal

Sahod Ulan 1 in Philippines
2 in 1: Drought + submergence tolerance

- Three drought yield QTLs pyramided in Swarna sub1
- BC$_4$F$_2$ population with three QTLs under genotyping at IRRI
- Anjali, Savitri, TDK 1, Saro 5, Supa, NSICRc 222, MR219, MRQ74 improvement underway
Rice is growing near its max temperature tolerance (33C)

• Extremely difficult to change basic biology of temperature sensitivity
  • Rice flowering is the only stage at which temperature is critical
  • Rice normally flowers at mid day…
• Maybe the best strategy is to just run away?
Conserving traditional heirloom rice varieties for indigenous livelihoods

Eighth Wonder, Inc
PO Box 89
Ulm, Montana 59485
www.heirloomrice.com
406-866-3340
Wild Species of *Oryza*: The Resource to Meet Tomorrow’s Challenges

- Insect resistance
- Disease resistance
- Drought, salt, flood, heat...
- Yield and nutrient use

**O. ridleyi**

**O. officinalis**

**O. minuta**

**O. alta**

**O. brachyanta**

**O. rufipogon**

**O. longistaminata**

**O. alta**

**O. minuta**

**O. brachyanta**

**O. rufipogon**

**O. longistaminata**
Transfer of natural salt tolerance from *Oryza coarctata* (KKLL genome), a wild species that grows well in brackish water.
Even in wild relatives, some traits are not found in rice
Approx. 400M suffer VAD globally, ~33%
SE Asia 100 -140 million children suffer from VAD

Effects:
• Child mortality
• Measles susceptible
• Night blindness
• Corneal scarring
• Blindness
Combating vitamin A deficiency among the poor: Golden Rice

Work on Golden Rice began in late 1980s... to consumers in 201??
Can Golden Rice Provide Sufficient Vitamin A?

β-Carotene in Golden Rice is as good as β-carotene in oil at providing vitamin A to children


GreenPeace ridiculed prototype Golden Rice as having insufficient β-carotene

1 Bowl of Golden Rice (50g uncooked, 150 g cooked) Provides 60% of Recommended Daily Dose for Chinese Children 6 years of age and younger
IRRI – GRiSP breeding hubs for South East and South Asia and ES-Africa

- **Hub S-A**
  - Pakistan
  - Nepal
  - Bangladesh
  - Myanmar
  - Cambodia
  - Vietnam
  - Sri Lanka

- **Hub ESA**
  - Uganda
  - IRRI office Bujumpura, Burundi
  - Kenya
  - Tanzania
  - Mozambique
  - Indonesia

- **Hub SE-A**
  - IRRI- HQ, Philippines

- **IRRI offices**
  - IRRI office, Hyderabad, India
  - IRRI office, Bujumpura, Burundi
What do we do about managing our rice crop more efficiently?

Examples of nutrient and water management
Rice and Water

40% of fresh water used in Asia goes to rice production

Puddling soil and transplanting seedlings controls weeds, improves nutrient supply & holds water later in season

As labor and water use change, what does this mean for rice production?
Expected increasing water scarcity

2025: 15-20 million ha irrigated rice will suffer some water scarcity

Asia WS irrigated rice

Comprehensive Assessment
Water Management in Agriculture
2007

IRRI Data base (GIS laboratory)
### Water saving options for rice

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Safe AWD</th>
<th>Dry seeded</th>
<th>Aerobic rice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land prep</strong></td>
<td>Puddled</td>
<td>Puddled</td>
<td>Not puddled</td>
<td>Not puddled</td>
</tr>
<tr>
<td><strong>Establishment</strong></td>
<td>Transplant; wet seed</td>
<td>Transplant; wet seed</td>
<td>Dry seed</td>
<td>Dry seed</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>Flooded; saturated</td>
<td>Saturated; mild drying</td>
<td>Early: drained; then saturated</td>
<td>Drained</td>
</tr>
<tr>
<td><strong>Soil aeration</strong></td>
<td>Anaerobic</td>
<td>Anaerobic; mild drying</td>
<td>Aerobic; then anaerobic</td>
<td>Aerobic</td>
</tr>
</tbody>
</table>

**Images:**
- **Conventional**
- **Safe AWD**
- **Dry seeded**
- **Aerobic rice**
15 years of research provides the science for ‘precise’ field-specific nutrient management.

Partnerships of > 15 years (1996-present)

Science is well documented.

Tools are available for farmers.

Farmers need quick and easy access to customized, science-based recommendations.
Farmer calls 2378 using Globe SIM

**Interactive Voice Response implementation box**

**GSM mobile**

**Smartphone**

**Web**

**Converted to HTML 5**

**Web output**

**Smartphone output**

**SMS output**

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**Nutrient Manager for Rice Philippines Version 2.1**

*Farm:*
- **Name:***
- **Cellphone number:**
- **Location:** Calabarzon, Nueva Ecija, Region III
- **Growth stage:** 3 ha
- **Variety:** IRRI 55 (Tiripan 15)

*Rice rape per year:***
- **Reason:** 1 ha
- **Direct seed:** 90
- **Days from seed to harvest:** 90

This information is illustrated below.

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>OAH***</th>
<th>Attraction yield***</th>
<th>Paddy yield***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>12–16</td>
<td>12–14/14</td>
<td>14/9/9 kg/ha</td>
</tr>
<tr>
<td>Anthesis</td>
<td>28–32</td>
<td>16–32</td>
<td>2/2/2 kg/ha</td>
</tr>
<tr>
<td>Paddy</td>
<td>40–47</td>
<td>16-32</td>
<td>2/2/2 kg/ha</td>
</tr>
</tbody>
</table>

*** OAH: Output at harvest

SMS: Converted to HTML 5

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Connect farmers with relevant agricultural science and services:

Suite of compelling services and financial products

Interactive Apps --- providing management guidelines

Product development and testing

1. Invest wisely at start of season
   - Nutrient Manager and Rice Crop Manager

2. Protect investment during season
   - Rice Crop Doctor

Input providers
Service providers

Insurance
Microfinance
Marketing

Nutrient Manager
Rice Manager
Rice Doctor
Variety and Seed Selector

Research
Validation

Consolidation of knowledge
Testing with farmers
Particular attention to women stakeholders

Burundi: ex-combatant women trained in novel rice farming technologies

“In my family… we were eating only once a day… now we eat twice a day”
For sound medium and long term planning, what do we need to know?

Location specific, timely and accurate information on rice production, supplies, and trends

In particular:

• What is the harvested area?
• When will it be harvested?
• What is the yield?

A combination of remote sensing and crop yield modeling can provide this information under certain conditions.
Mapping rice from space

Regular monitoring of rice growing areas using satellite imagery, modeling and regional ground-truthing to accurately estimate rice area, rice production and damage from calamities.
How the technology works

Optical data is based on sunlight

and clouds are a problem

Radar data is not based on sunlight

can see through the clouds
Mekong Delta, Vietnam

• Over 85% accuracy in the rice area estimates at 3m resolution.
• SAR can also capture the variability in planting dates and cropping patterns.
Yield and production estimates at the end of season, plans to generate yield forecasts at 30 and 60 days before harvest.
Typhoon Haiyan November 2013
National/Global Rice Information Gateways

Policy makers

Medium-term projections
Analysis of policy impacts

Rice supply-demand-trade model

Crop growth models
Monitoring and short-term forecasting
Statistics, GIS Remote sensing

Crop growth models

Statistics, GIS
Remote sensing
We Are Faced With…

• Surge of new technologies and potential technologies to benefit changing rice community
  • The way rice will be grown and marketed to meet demand in a changing climate…

• Surge in the demand for these technologies
  • How best to reach diverse rice farmers
  • Transformational interest of private sector in the rice sector

• Increased risks of catastrophic losses
• Need for pre-disaster mitigation tools
"Precious things are not pearls and jade but the five grains…, of which rice is the finest"

- Ancient Chinese saying
THANK YOU
Help us fill the world’s rice bowls

Come join us!

http://irri.org/JoinUs
Thank you for joining us!

Share Feedback
Take a moment to respond to our Polls.
You can also visit the event page to post comments & questions.

Stay In Touch
Contact Us:
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OR
Julie MacCartee,
USAID/BFS
jmaccartee@usaid.gov

Upcoming Events
Webinar | Emergency Seed Systems | Oct 9
Ag Sector Council | Smallholders to Shareholders
July 28 – Aug 1

Agrilinks and the AG Sector Council Seminar Series are products of the USAID Bureau for Food Security under the Feed the Future Knowledge-Driven Agricultural Development (KDAD) project.