Small-Holder Agriculture...
Current Challenges and Future Opportunities

Adrian Johnston
Asia & Africa Coordinator
IPNI, Saskatoon
IPNI is supported by leading fertilizer manufacturers and industry associations

Agrrium Inc.
Arab Potash Company
Belarusian Potash Company
CF Industries Holdings, Inc.
Great Salt Lake Minerals
Incitec Pivot
International Raw Materials LTD.
Intrepid Potash, Inc.
K+S KALI GmbH

The Mosaic Company
OCP S.A.
PotashCorp
Simplot
Sinofert Holdings Limited
SQM
Uralkali
Vale Fertilizantes S.A.

Anda - Associação Nacional para Difusão de Adubos
Arab Fertilizer Association (AFA)
Canadian Fertilizer Institute (CFI)
The Fertilizer Association of India
International Fertilizer Industry Association (IFA)
International Potash Institute (IPI)
The Fertilizer Institute (TF)
- 30 Ph.D. scientists in 10 program areas
- 140 R&D projects in 2010, 75% dealing with increasing yields
Global Population and Food Security

- Population increases are placing greater pressure on the food security of certain regions of the world.
- Question is, who is going to face food security problems, and at what cost?
Food Security

• “Food security is a global challenge, played out on a local scale”.

• “Challenges of this scale (food security) have been met in the past – between 1961 and 2008, agriculture output increased by 179 percent globally. In many parts of the world, these production increases were achieved by intensification”.

Brian Keating and Peter Carberry, CSIRO, Australia
## World Population – Projected Changes

Values shown are %

<table>
<thead>
<tr>
<th>Year</th>
<th>World</th>
<th>Asia</th>
<th>Africa</th>
<th>Europe</th>
<th>L.A.</th>
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World Population database, FAO, 2008
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World Population database, FAO, 2008
Fertilizer use

Average per hectare fertilizer use rates as kilograms of nutrients (NPK) by fertilizer markets in 2008/09

Source: IFDC; derived from FAO data
Smallholder Farmers... Who are they?

- Smallholders represent 2.5 billion of the current 7.0 billion people living in the world today.
- Their land holdings are small...based on population pressure, but usually less than 2.0 ha (5 ac). In populated areas they often have less than 0.5 ha (1.0 ac).
- Hand labor (planting, weeding, fertilizing, harvesting), with some animal support.
- Family based...man, woman and children.
Smallholder Farmers…
Who are they?

• Often very dependent on cheap local labor to support their farming activities...a growing challenge.
• Smallholders often eat a significant portion of their production, leaving little to sell and generate income.
• When asked what they would do with more cash, they rarely indicate that they would use it for more production. School fees, fix the house, buy livestock, buy some meat, are often the responses.
Reality check - India

- A good farmer in Eastern India, with 0.5 ha, produces about 8 t/ha/year of rice
  - His operational cost is $700 for the two rice crops
  - For a 5 member family, his own consumption is 1 t rice/year
  - For 7 t rice his income is about $980
  - After deducting the operational cost, he is left with $280 ($0.77/day)

- Let's assume that his 3rd crop is mustard with yield potential of about 1.4 t/ha
  - His income from this crop is $476
  - Assume cost of cultivation is $200
  - Earning is $276

- He is left with US$556/year or US$46/month ($1.52/day)...and there are 400 million in the same position in India.
Who is minding the farm in China?
Reality Check - China

• A good farmer in wheat and maize rotation area, with 0.3 ha, produces about 15 t/ha/year of wheat and maize:
  – His operational cost is $231 for two crops, family consumption is $770.
  – For the wheat and maize from 0.3 ha he sells his income is about $1,523.
  – After deducting the operational cost and personal use, he is left with $523.

• A good farmer in vegetable growing area, with 0.3 ha (2 greenhouses) and 2 crops/year, earns $7,077 (net).

• Therefore he left with US$523 (grain crops), or US$7,077 (vegetables) as a yearly income, or $1.43/day or $19.39/day.
Future of Smallholders...?

- Children being encouraged to leave to escape the poverty
- Land rental becoming more common
- Sad, but a reality in the evolution of agriculture production, globally
- Impacts on decisions by agencies focused on global agriculture development
Analyzing farmers’ practice: Yield gaps

Relative yield (%)

- Yield gap 3
- Actual yield
  - (Y)
- Yield gap 2
  - Attainable yield in average seasons
  - (Ya)
- Yield gap 1
  - Maximum attainable yield in very favorable seasons
  - (Ya max)
- Yield potential
  - (Yp)
Sub-Saharan Africa
The context of smallholder farming systems

Village land (600 ha)

Communal grazing land

Fodder

Manure

Wealthier farmers’ cropland

FZ4 (25 ha)

FZ2 (46 ha)

FZ2 (43 ha)

Livestock

Grazing of crop residues

3 t ha⁻¹

5 t ha⁻¹

Wet and dry season grazing

Poorer farmers’ cropland

FZ4 (86 ha)

FZ2
Impact of Soil Quality on Nutrient Response

Malawi data, Zingore et al. (2009)
Fertilizer use an important factor

Vanlauwe et al. 2010
Obstacles Farmers Face

Low Yields
Need good seed and fertilizer on time

Lack of Financing
Seasonal income at a low point during planting

Lack of Knowledge
Little access to extension services

Lack of Markets
Need more market and storage options

Development program goals:
100% increase in farm income
Donor Agency Approaches to Africa

<table>
<thead>
<tr>
<th>Farmer Obstacles</th>
<th>Solution</th>
</tr>
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<tr>
<td>Lack of Knowledge</td>
<td>Little access to extension services</td>
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<tr>
<td>Low Yields</td>
<td>Need good seed and fertilizer on time</td>
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<td>Lack of Financing</td>
<td>Seasonal income at a low point during planting</td>
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<tr>
<td>Lack of Markets</td>
<td>Need more market and storage options</td>
</tr>
<tr>
<td><strong>Low Yields</strong></td>
<td><strong>1) Inputs</strong> Fertilizer &amp; certified seed delivery to village</td>
</tr>
<tr>
<td><strong>Lack of Financing</strong></td>
<td><strong>2) Credit</strong> Group lending makes farmer credit possible</td>
</tr>
<tr>
<td><strong>Lack of Knowledge</strong></td>
<td><strong>3) Education</strong> Training in farmer fields and weekly follow-up</td>
</tr>
<tr>
<td><strong>Lack of Markets</strong></td>
<td><strong>4) Markets</strong> Harvest buyback and storage training</td>
</tr>
</tbody>
</table>

A complete value chain
Field Innovations - Fertilizer

• Fertilizer Scoop –
  • micro-dosing
  • Precision placement

• Fertilizer Blending –
  DAP/Granulated lime blend
  - micro-targeting: move towards customized blends.

* Fertilizer Adoption and Behavior Change
* Fertilizer and new products, e.g. bananas
Fertilizer Blending

Dry Blending Plant

Compounding Plant

ARM Mining and Fertilizers, Nairobi
Africa and Food Security

- Africa annually imports $50 Billion USD of food materials
- Has become very reliant on food aid from donors...resulting in “donor fatigue”
- CG report states “..Africa could become a net exporter of both rice and maize using current technology.”
South Asia
South Asia’s biggest challenge...low yields

Average yield of food grains in India is 1,900 kg/ha, while the same crops average in China is 5,300 kg/ha...some water...lots of nutrients!
Rice and wheat yield growth in South Asia

**Short-term:**
- Delivery (1)
  - Seeds
  - Agronomy
  - Postharvest
- Ext. capacity (7)

**Medium-term:**
- Improved varieties (3, 4, 5):
  - drought & heat tolerant
  - resistant to key biotic stresses
  - adapted to new systems
- Improved cropping systems (2)
- Science capacity (7)

**Long-term:**
- Improved varieties (3, 4, 5):
  - yield potential (R, W)
  - biotech (drought, NUE, salinity)
- Improved cropping systems (2)
- Science capacity (7)

**Target range**
- >1.5%/yr
- 1.2-1.5%/yr
- 1%/yr
- <1%/yr

**Do nothing**
- <1%/yr

**Targeting and Policies (6)**
Making fertilizer recommendations in S.Asia
IPNI Research Trials
**Nutrient deficiency status in SSNM experiment (high yield target) under rice-wheat system**

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<tr>
<th>Centers</th>
<th>Nutrient deficient</th>
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<tr>
<td></td>
<td>P</td>
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<td>PDCSR, Modipuram</td>
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<td>GBPUA&amp;T, Pantnagar</td>
<td>✓</td>
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<td>CSAUA&amp;T, Kanpur</td>
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<td>NDUUA&amp;T, Faizabad</td>
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<td>BHU, Varanasi</td>
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<td>HPKV, Palampur</td>
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<td>PAU, Ludhiana</td>
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<td>R S Pura</td>
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IPNI, 2006
Nutrient Use Efficiency in Asia
Manure Management
Effect of P deficiency in Corn
IPNI funded SSNM research in Comilla, Bangladesh
K Omission plot (left) vs. full NPK plot (right) at Comilla, Bangladesh
### Effect of SSNM practices on productivity (t/ha) of wheat under RWCS

<table>
<thead>
<tr>
<th>Site</th>
<th>FP</th>
<th>SR</th>
<th>SSNM</th>
<th>% increase over SR</th>
<th>% increase over FP</th>
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<td>Palampur</td>
<td>2.64</td>
<td>3.76</td>
<td>3.87</td>
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<td>46.5</td>
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</tbody>
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SR = State recommendation, FP = Farmer,s practice

Tiwari et al., 2006
South Asia and Food Security

- Region has annual imports $1.5 Billion USD of food aid, the bulk of which goes to Pakistan
- Most countries are self sufficient at this time
- Very large unused productivity potential...easy to double yields in region with available technology.
- Government subsidies have a major impact on future success in the region
China
China in 2012

• China food grain production continues to rise each year, especially corn and rice.

• However, land continues to disappear to industrial development and cities.

• The labor challenge in China is serious, with all able bodied men and women leaving for work in construction.

• Mechanization is rapidly taking hold in the country…labor issue.

• Over-use of N and P very common.

• Food security is a major concern, reflected in the movement of China to support development in Africa.
Maize-Winter Wheat System
Fruits and Vegetables
### Soil Test

Local Recommendations for fertilizer in China:

<table>
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<tr>
<th>N</th>
<th>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</th>
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Soil Test

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Local Recommended

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Making fertilizer recommendations in China
Fertilizer use in China...Future Prospects

- Chinese crop production increases are impressive:
  - >75% increase in food grains in the past 20 years,
  - >250% increase in fertilizer use,
  - However, they have shown a -54% change in PFP?

- Estimates are that there is a 30-60% overuse of N fertilizer in China, mainly driven by the pressure to meet food security targets.
  - Amounts to 12 mmt of fertilizer N = 50-60 kg N/ha in all of SSA...

- This raises the question of how “eco-efficient” some production systems are, when others are so degrading.

Brian Keating and Peter Carberry, CSIRO, Australia
CIALCA conference, Kigali, Rwanda – October, 2011
Changes of crop structure

Grain crops

Vegetables

Fruit

Grain crops

Vegetables

Fruit

1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2008

M ha

M ha
Nutrient balance in farmland in China

N surplus (kg/ha)

- Grain crops
- All crops

P$_2$O$_5$ surplus (kg/ha)

- Grain crops
- All crops

K$_2$O surplus (kg/ha)

- Grain crops
- All crops

Liu, Xiaoyan, 2008
Burning straw in the fields
Mechanization is developing and more straw is returned to crop land

Maize stalk return

Wheat straw mulch
The Focus is on Everyone Growing Their Own Food
Thank You