“Agricultural productivity and the impact of GM crops: What do we know?”

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- Growth in agricultural productivity has important implications for food security and food prices
- Net food importing countries have rapidly growing populations and growing food demand per capita, plus poorer land and water availability
- There are significant yield gaps in many African importing countries (Matthews, 2014)
- Investment in R&D could significantly increase production and productivity growth – Brazil, India and China now account for 31% of public research
20th Century – growth in food supply outweighed growth in demand, driving down real food prices

Recent price spikes are last step in slowing down in rate of decline in real food prices since 1970s

Consistent with productivity slowdown - global average yields for key crops have fallen:

<table>
<thead>
<tr>
<th>Crop</th>
<th>1961-1990</th>
<th>1990-2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>2.33</td>
<td>1.77</td>
</tr>
<tr>
<td>Wheat</td>
<td>2.72</td>
<td>1.09</td>
</tr>
<tr>
<td>Rice</td>
<td>2.14</td>
<td>1.06</td>
</tr>
<tr>
<td>Soybeans</td>
<td>1.72</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Source: Alston and Pardey (2014)
Real US Prices of Corn, Soybeans and Wheat, 1924-2012

Source: Alston and Pardey (2014)
- Public expenditure on agricultural R&D has been declining in developed countries - share in total dropped from 56% to 48% between 1960 and 2009
- Increasing share of their spending going to off-farm issues, e.g., health and nutrition
- Changes in patent law have provided incentives to private firms to invest in development of GM crops – corn, soybeans, cotton and rapeseed
- 1.25 billion acres planted to GM crops since 1996
- What do we know about impact of first-generation GM crops on agricultural productivity?
### GM Area Harvested in 2010 (millions of acres)

<table>
<thead>
<tr>
<th></th>
<th>Cotton</th>
<th>Soybeans</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>23.2</td>
<td>US</td>
</tr>
<tr>
<td>US</td>
<td>10.1</td>
<td>Brazil</td>
</tr>
<tr>
<td>China</td>
<td>8.6</td>
<td>Argentina</td>
</tr>
<tr>
<td>Argentina</td>
<td>1.5</td>
<td>Paraguay</td>
</tr>
<tr>
<td>ROW</td>
<td>3.2</td>
<td>ROW</td>
</tr>
</tbody>
</table>

#### Cotton
- **India**: 90% of area
- **US**: 85% of area
- **Argentina**: 90% of area

#### Soybeans
- **US**: 92% of area
- **Brazil**: 85% of area
- **Argentina**: 85% of area
- **Paraguay**: 90% of area

<table>
<thead>
<tr>
<th></th>
<th>Corn</th>
<th>Rapeseed</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>69.7</td>
<td>Canada</td>
</tr>
<tr>
<td>Brazil</td>
<td>18.5</td>
<td>US</td>
</tr>
<tr>
<td>Argentina</td>
<td>6.9</td>
<td>Australia</td>
</tr>
<tr>
<td>South Africa</td>
<td>4.7</td>
<td>ROW</td>
</tr>
<tr>
<td>ROW</td>
<td>4.7</td>
<td>0.0</td>
</tr>
</tbody>
</table>

#### Corn
- **US**: 85% of area
- **Brazil**: 85% of area
- **Argentina**: 85% of area

#### Rapeseed
- **Canada**: 85% of area
- **US**: 85% of area
- **Australia**: 85% of area
- **ROW**: 85% of area

*Source: Barrows et al. (2014)*
Adoption of GM crops occurs along two margins:

- **intensive margin** - conventional seed is replaced with GM variety
- **extensive margin** - previously unused land recruited into production, switch from other crops, and double-cropping

GM cotton, corn and rapeseed mostly adopted along intensive margin

In contrast, adoption of GM soybeans adopted evenly along both margins – 50% increase in acreage mostly in Brazil and Argentina
Adoption of GM Technology

Profit/acre vs. Pest Damage

- Traditional technology
- GM technology

Intensive margin vs. Extensive margin
World Area of Four Crops with GM Varieties (1 hectare = 2.47 acres)

Source: Barrows et al. (2013)

- Potential for yield gains from GM technology likely greatest where pest pressure is high, i.e., in low income developing countries
- Most GM yield estimates based on randomized control tests – farmer behavior held constant, i.e., a pure “gene effect”
- Diminished crop damage increases marginal value of other inputs – generates extra yield gains
- Impact on extensive margin depends on whether additional production would have occurred in absence of GM crops
Yield effects at intensive and extensive margins:

- 2-14% to 9-19% increase in corn yields
- 0-25% to 5-29% increase in cotton yields
- 2-39% increase in soybean yields

Adoption of GM corn, cotton and soybeans has lowered prices by 13%, 18% and 2-65% respectively (Barrows et al., 2013)

Global net benefit to producers estimated at $65 billion over period 1996-2009, $30 billion accruing to US producers (Brookes and Barfoot, 2012)
Adoption of first-generation GM crops has had positive impact on productivity, with associated impact on prices and land-use

GM corn adoption limited to 30% of global acreage – affected by bans/regulatory restrictions in China, EU and Africa

Currently - no commercial use of GM technology in key food grains rice and wheat

Important to recognize calorie substitution between wheat, rice and corn (Wright, 2014)
Public concern about safety of GM crops has slowed approval and release of GM rice and wheat

- GM rice approved by China in 2009, but not fully commercialized
- Monsanto dropped development of GM wheat in 2004

China an interesting case: significant public funding of biotechnology R&D, and has approved feed-grains for import – but public skepticism about growing GM crops for human consumption