Potential Impacts of Golden Rice on Public Health in India

Alexander J. Stein,* H.P.S. Sachdev° and Matin Qaim*

*University of Hohenheim, Stuttgart, Germany
°Sitaram Bhartia Institute of Science and Research, New Delhi, India

26th Conference of the International Association of Agricultural Economists, 12-18 August 2006, Gold Coast, Queensland, Australia

Introduction

• 140 million pre-school children & 7 million pregnant women suffer from vitamin A deficiency (VAD) worldwide
• Up to 3 million children die every year & many become blind
• The current intervention of choice is bi-annual medical supplementation with mega-doses of vitamin A (VA)
• Rising coverage rates are achieved
Introduction

• Supplementation is resource intensive (funding, manpower, infrastructure, monitoring)
• Those most in need may not be reached (in remote areas or at the fringes of society)
• VAD is an essentially food-based problem but supplementation is a medical intervention
• A more sustainable approach would to be to improve dietary VA intake
• Income growth (via higher quality food) will not improve nutrition any time soon

Introduction

• Rice-eating populations are at particular risk because milled rice does not contain beta-carotene (a precursor of VA)
• For the same reason it cannot be cross-bred into the endosperm of rice
• A genetic engineering approach was successful as a proof-of-concept (Golden Rice)
• The potential impact & cost-effectiveness of GR remains disputed
• In India VAD is prevalent & GR is researched
Methods & data

- GR is an agricultural product but common agricultural economics methods for impact assessment cannot be used
- Beneficiaries of GR have no purchasing power
- The benefit of GR is improved health
- Cultivation/consumption needs to be linked to health outcomes to capture benefits
- How to measure health across target groups and different health outcomes?
- Namely night blindness, corneal scars, blindness, measles & child mortality

- Counting VA deficient individuals neglects the severity of different health outcomes
- For premature mortality the years of life lost (YLL) can be counted
- In the other cases the years lived with disability (YLD) can be counted
- The severity of these health outcomes can be weighted relative to death
- Then the burden of a disease can be expressed in disability-adjusted life years (DALYs) lost
Methods & data

• Burden = \( \text{DALYs}_{\text{lost}} = \text{YLL} + \text{YLD}_{\text{weighted}} \)
• More formally:

\[
\text{DALYs}_{\text{lost}} = \sum_j T_j M_j \left( \frac{1 - e^{-rL_j}}{r} \right) + \sum_i \sum_j T_j I_{ij} D_{ij} \left( \frac{1 - e^{-rd_{ij}}}{r} \right)
\]

• Comparing the burden with and without GR gives its impact in terms of a health gain
• How to relate the improved VA intakes to improved health outcomes?
Methods & data

- Given the health gains expressed in DALYs the improvement relative to the overall disease burden can be derived
- The absolute number of DALYs saved can be juxtaposed to the overall R&D costs of \( \text{GR} \) to obtain a cost-effectiveness measure ($/DALY)
- To take account of the uncertainty surrounding ex-ante analyses a scenario approach is used
## Methods & data

<table>
<thead>
<tr>
<th>Impact scenario</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>β-carotene content in GR (µg/g)</td>
<td>14</td>
<td>31</td>
</tr>
<tr>
<td>Post-harvest loss of β-carotene (%)</td>
<td>80</td>
<td>35</td>
</tr>
<tr>
<td>Conversion of β-carot. in GR into VA</td>
<td>6:1</td>
<td>3:1</td>
</tr>
<tr>
<td>Coverage of GR 15 yrs after release</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- government shops &amp; schools (%)</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>- on the free market (%)</td>
<td>14.3</td>
<td>50</td>
</tr>
<tr>
<td>Average annual cost over 30 yrs ($)</td>
<td>713,000</td>
<td>931,000</td>
</tr>
</tbody>
</table>

## Results

<table>
<thead>
<tr>
<th>Impact scenario</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual burden of VAD (DALYs lost)</td>
<td>2.3 million</td>
<td></td>
</tr>
<tr>
<td>No. of lives lost due to VAD each year</td>
<td>71,600</td>
<td></td>
</tr>
<tr>
<td>Reduction of the burden through GR</td>
<td>8.8% 59%</td>
<td></td>
</tr>
<tr>
<td>No. of children’s lives saved through GR</td>
<td>5,500 39,700</td>
<td></td>
</tr>
</tbody>
</table>
### Results

<table>
<thead>
<tr>
<th>Impact scenario</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost-effectiveness of GR (US$/DALY)</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>World Bank benchmark (US$/DALY)</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>WHO standard for valuing DALYs (US$)</td>
<td>620 - 1,860</td>
<td></td>
</tr>
<tr>
<td>US$/DALY saved with supplementation</td>
<td>134 - 599</td>
<td></td>
</tr>
</tbody>
</table>

- Results of different scenarios and various sensitivity analyses not reported here

### Conclusion

- **GR** has the potential to be an effective & efficient intervention to fight VAD
- **GR** on its own will not eliminate VAD
- The inclusion of **GR** in more comprehensive public health strategies should be considered
- Other useful interventions are targeted VA supplementation, nutrition education & poverty reduction
Conclusion

- Future research has to determine the exact size of crucial parameters like
  - the beta-carotene content that can be realised under field conditions
  - the magnitude of post-harvest losses of beta-carotene
  - the agronomic performance of GR-varieties
  - and the acceptability of GR by consumers
- The safety of GR for human consumption & the environment will have to be assessed and GR be regulated by national authorities

Thank you

for your attention!