Bt Cotton Adoption and Wellbeing of Cotton Farmers in Pakistan

By

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Plan of Presentation

• Background

• Research gaps and objectives

• Analytical framework and data

• Results

• Conclusions

• Limitations and policy implications
Background – Pakistan and Cotton

- 4\textsuperscript{th} largest producer
- 3\textsuperscript{rd} largest consumer

- Cotton and textiles contribute
  - 8\% to GDP
  - 17\% to employment
  - 54\% to export earnings (yarn and finished textile products)

- Cotton farmers’ problem
  - high fluctuations in yield due primarily to pest infestation
    - resulting in high cost of production (25-30\% on plant protection)
Background

• Bt cotton addresses crop loss by controlling the pest infestation (Pray et al., 2001; Ismael et al., 2002; Qaim and de Janvry, 2003; Traxler et al., 2003; Qaim, 2003; Gandhi and Namboodiri, 2006)
  • Cost advantages (lower pesticide expenditure)
  • Yield advantages
  • Higher profit than conventional varieties

• Bt technology is IPR protected,
  • commercial adoption is conditional on a per acre fee (technology fee) paid to the owners of the gene ⇒ high seed price

• Among four large cotton producing countries, Pakistan is the only one that has not formally adopted Bt cotton under IPR “commercial adoption”

• However, the cultivation of Bt cotton, although unapproved and unregulated, increased rapidly after 2005 (PARC, 2008)
Research Gaps and Objectives

• Impact of Bt cotton in Pakistan - (Hayee, 2004; Sheikh et al., 2008; Arshad et al., 2009, Ali and Abdulai, 2010) - why yield/hectare is declining?
  – Lack of in-depth research on the impact of Bt cotton under different agro-climatic conditions in Pakistan

• Previous analyses are based on the difference of means tests
  – When sample is drawn from non-experimental design, the difference of means method may give biased results

• Objectives:
  – To estimate the impact of adoption of Bt cotton (causal effect) on the wellbeing of cotton farmers under different agro-climatic conditions
  – Cotton yield, profit, household per capita income and poverty headcount are used as wellbeing indicators
Analytical Framework: Measuring Causal Effect

- The causal effect of a treatment (e.g., technology adoption) is the difference between outcomes with treatment ($Y_1$) and without it ($Y_0$):
  \[
  \text{treatment effect} = Y_1 - Y_0
  \]

- Impact evaluation can suffer from two problems
  - Selection problem: individuals select themselves into treatment if they perceive $U(Y_1) > U(Y_0)$
  - Evaluation problem: for the same individual, either $Y_1$ is observed or $Y_0$

- Problem of missing counterfactual:
  - How much did the treated individuals benefit from the treatment compared to the situation if they would not have been treated?

- Average Treatment Effect: $\text{ATE} = [E(Y_1)|I=1] - [E(Y_0)|I=0]$
- Average Treatment effect on the Treated: $\text{ATT} = [E(Y_1-Y_0)|I=1]$
## Analytical Framework: Estimation Methods

<table>
<thead>
<tr>
<th>Methods</th>
<th>Advantages/disadvantages</th>
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<tbody>
<tr>
<td>Difference of means</td>
<td>Difficult to isolate the true effect if treatment is not random</td>
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<td>OLS</td>
<td>Does not control self-selection bias if treatment is not random</td>
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<td>IV/2SLS</td>
<td>Controls selection bias, problem in finding out right instrument</td>
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<tr>
<td>Heckman’s two-steps</td>
<td>Controls selection bias, does not examine the counterfactual situation</td>
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<tr>
<td>Difference in difference</td>
<td>Requires panel data</td>
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<tr>
<td>Propensity score matching</td>
<td>Addresses the issue of selection bias and examines counterfactual</td>
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</table>
Analytical Framework
(Propensity Score Matching)

• When treatment is not randomly assigned
  • \( E[Y_{0i}|I=0] \neq E[Y_{0i}|I=1] \)

• PSM creates a good counterfactual
  • Treated and non-treated units have identical characteristics except the decision of being treated (unconfoundedness)
  • Treated and non-treated units should be overlapped
  • Estimate propensity score (logit or probit model)
  • Matching (treated with non-treated) using matching algorithm (nearest neighbour, radius, kernel, and stratification matching)
  • Creates \( \Rightarrow E[Y_{0i}|I=0] = E[Y_{0i}|I=1] \Rightarrow \) situation similar to random assignment
  • Estimate average treatment effect on the treated (ATT)
Data

• Cotton farmer survey in 2009

• Two districts (Bahawalpur and Mirpur Khas)

• These districts similar in terms of development ranking and incidence of poverty but have different agro-climatic conditions:
  – Bahawalpur (hot and dry - non-bollworm pests)
  – Mirpur Khas (hot and humid - bollworm pests)

• 16 villages and 208 cotton farmers
Basic Facts: Selected Households

• Farm size
  – 81.6% operate less than 12.5 acres of land.
  – most of them are concentrated in the category less than 5 acres

• Type of tenure
  – 77.9% farmers in Bahawalpur are owner
  – most of the sharecroppers are in Mirpur Khas (73.1%)

• Bt cotton adoption rate is high
  – 87% in Mirpur Khas
  – 74% in Bahawalpur

• The level of awareness about Bt technology and its use is extremely low in both districts
  – farmers do not know the name of seed variety or the seed company
  – farmers do not have any knowledge about the importance of seed quality and the refuge area
Results:
Three Estimation Techniques (Full Sample)

- **Gross margin**
- **Total expenditure**
- **Seed expenditure**
- **Non-bollworm expenditure**
- **Bollworm expenditure**
- **Pesticide expenditure**

**Yield**

- Positive and significant impact on per capita household income in all methods
- Insignificant impact on poverty headcount

**Rs/acre**

**Kg/acre**
Results:
Three Estimation Techniques (Bahawalpur)

Positive and significant impact on per capita household income in DM and Heckman but insignificant in PSM.

Insignificant impact on poverty headcount.
Results:
Three Estimation Techniques (Mirpur Khas)

Positive and significant impact on per capita household income in DM and PSM but insignificant in Heckman
Insignificant impact on poverty headcount
Results:
Large Vs Small Farmers using PSM (Full sample)

- Positive and significant impact on per capita household income for large farmers, and insignificant impact on small farmers.
- Insignificant impact on poverty headcount.

![Bar chart showing comparisons between large and small farmers across different expenditures categories](chart.png)
Conclusions

• Impact of Bt cotton varies across agro-climatic conditions
  – More effective in the areas with hot and humid weather where bollworm pressure is high

• Impact on wellbeing indicators is overestimated if the issue of self-selection bias is not addressed

• In the area of high bollworm pressure, even after addressing the issue of self-selection bias, Bt cotton results in:
  – higher yield, higher Profit, and higher per capita income (consistent with Ali and Abdulai, 2010)
  – Increase in income is not enough to reduce poverty (inconsistent with Ali and Abdulai, 2010)

• Bt cotton appeared effective for both large and small farmers – per acre gains for large farmers are higher
Limitations and Suggestions

• Small sample survey – did not allow disaggregation
  – Due to the high diversity of the cotton-growing areas, large sample size with more location-specific information should be selected

• Lack of data on the quantities of pesticide and on detailed disaggregated information on labour use (family and hired – both casual and permanent)
  – Such data could be analysed using appropriate methods
Policy Implications

• Commercialize Bt cotton in regularized seed market

• Conduct regular surveys to monitor pest pressure and performance of Bt cotton

• Address the needs of small farmers through institutional support (information flow, provision of credit and availability of inputs)
Thank You
Yield (Kg/hectare) in Selected Countries

<table>
<thead>
<tr>
<th>Year</th>
<th>World</th>
<th>China</th>
<th>India</th>
<th>Pakistan</th>
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<tbody>
<tr>
<td>1970</td>
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<td>1972</td>
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<td>2008</td>
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</table>
Yield (Kg/hectare) in Punjab and Sindh

![Graph showing yield trends in Punjab and Sindh over years from 1980-81 to 2008-09. The graph compares yield fluctuations with blue and red lines representing Sindh and Punjab respectively.]
Comparison of Pakistan’s Unapproved Bt Varieties with China and India’s Approved Bt Varieties

<table>
<thead>
<tr>
<th></th>
<th># of Sprays</th>
<th>Percentage difference in Bt and non-Bt varieties</th>
<th>Gross margin (US$/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pesticide cost</td>
<td>Seed cost</td>
</tr>
<tr>
<td>China (2001)</td>
<td>--</td>
<td>-58.1</td>
<td>333.3</td>
</tr>
<tr>
<td>India (2006)</td>
<td></td>
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<tr>
<td>Gujrat</td>
<td>--</td>
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<td>136.8</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>-1.9</td>
<td>-21.3</td>
<td>192.4</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>-3.8</td>
<td>-25.8</td>
<td>173.1</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>-2.0</td>
<td>-54.5</td>
<td>237.0</td>
</tr>
<tr>
<td>Pakistan (2009)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bahawalpur</td>
<td>-0.9</td>
<td>-21.1</td>
<td>64.9</td>
</tr>
<tr>
<td>Mirpur Khas</td>
<td>-1.9</td>
<td>-26.8</td>
<td>76.3</td>
</tr>
</tbody>
</table>
Agro-climatic Zones of Pakistan
### Basic Facts: Selected Districts

<table>
<thead>
<tr>
<th></th>
<th>CW-Punjab</th>
<th>CW-Sindh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence of poverty (%) (2005-06)</td>
<td>29.3</td>
<td>32.4</td>
</tr>
<tr>
<td>% of rural population</td>
<td>17.42</td>
<td>10.34</td>
</tr>
<tr>
<td>% of rural poor</td>
<td>17.76</td>
<td>11.11</td>
</tr>
<tr>
<td>Development Rank (2001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bahawalpur</td>
<td>Mirpur Khas</td>
</tr>
<tr>
<td></td>
<td>64/100</td>
<td>65/100</td>
</tr>
<tr>
<td>Weather</td>
<td>Hot and dry</td>
<td>Hot and humid</td>
</tr>
<tr>
<td>Soil quality</td>
<td>Sandy</td>
<td>Clay</td>
</tr>
</tbody>
</table>
Pest infestation in Punjab (2007 and 2008)