THE IMPACT OF CLIMBING BEAN ADOPTION ON WELFARE OF SMALLHOLDER COMMON BEAN GROWERS IN RWANDA

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Josephat Mugabo
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Outline

• Setting the context--
  • Role of bean in the household welfare of Rwanda
  • Why climbing bean is an innovation in Rwanda
  • Selected achievements of collaborative research in Rwanda

• Data – used to assess adoption and its impact on welfare

• Key results
• Implications and future direction
Setting context

**Rwanda:**

- < 1 Ha
- Over 80 % of the population--- Agriculture

**Per capita bean consumption**

- 38kg/year
- 79-88% of bean consumed comes from own production (NAS, 2008)

**Prevalence of food insecurity, poverty and malnutrition are high**
Beans and food security in Rwanda

---Number of days in a week different food groups are consumed, by household food consumption group

No. HH
=1,717,000
=378,000
=82,000

Weight

Source: WFP, MINAGRI NISR 2012
Elements of the collaborative Research on climbing bean in Rwanda

- Varietal adaptation to medium altitudes
- Improve resistance to biotic stresses
- Innovate- staking materials
- Enhancement-- seed systems

Climbing bean grows upwards requiring less land to produce the same amount of output (Musoni et al. 2001)
Achievements of the collaborative research 1984-2010

▪ What is known?
  ▪ About 48 of climbing type varieties (PABRA data base, 2015)
  ▪ Climbing bean occupies --43 % of the area cultivated with beans up from less than 20% in 1993 (Sperling and Muyaneza, 1995; Katungi et al 2015),
  ▪ Positive growth in bean productivity
    ▪ National average bean yield has grown from 688 kg/ha in 1990s to 928kg/ha in 2013 (FAO, 2014)
    ▪ Bean yield among adopters of improved varieties would be 56% less if had not been adopted (Larochelle et al. 2013)
    ▪ Per capita imported bean reduced from about 0.8 kg in 1985 to about 0.44kg per year in 2011 (FAO 2014)
  ▪ Stimulated a lot of interest to scale out the research effort to other countries

▪ What is less known?
  ▪ Contribution of climbing bean to the welfare of producers
Sample design and data collection

• National representative
• Stratification based on the 10 major agro-ecological zones in Rwanda
• 27 districts
• 80 villages based probability distribution
• Random selection of 18 households per community
• 1440 households
• Half of sample interviewed on consumption expenditure

Variety identification a systematic process

Variety disaggregated adoption, yield and sales data
Data used......

- 1st Round (April-May 2011)
  - Household questionnaire: HH composition, social capital, assets, knowledge and adoption, production (planting), marketing, access to ag. inputs
- 2nd Round: (Sept.-Oct. 2011)
  - Household questionnaire: production (labor, inputs, harvest), marketing, HH food security, constraints
  - Random selection of a maximum of 5 adopters and non-adopters in each village-- interviewed for consumption expenditures (n=704)
  - Consumption questionnaire: Food expenditures (7 days), non-food expenditures (30 days), and rent/land expenditures
  - Community questionnaire: Village info, market access, access to productive resources, production shocks and commodity prices
  - Collected bean samples in various villages—variety identification
  - Consumption expenditure was adjusted for differences in household composition and spatial prices—Paasche index
Diffusion of climbing bean across Agro-ecological zones of Rwanda, 2011

- NATIONAL
- LES SAVANES DE L EST ET DU BUGESERA...
- LES HAUTES TERRE DE BUBERUKA
- LES CRETES ET PLATEAUX BORDANT LES...
- LES ZONES ET HAUTES PLAINES...
- LE PLATEAU CENTRAL
- LE MAYAGA ET BUGESERA PERIPHERIQUES
- LE BORD DU LAC KIVU
- LA PLAINE DE BUGARAMA
- LA CRETE ZAIRE - NIL
- LARRIERE PAYS DE CYANGUGU

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Bush plots  Climbing bean plots
Average amount of seed and harvests by bean type, 2011

<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Bush only</th>
<th>Climbers only</th>
<th>Bush and Climbers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (Std)</td>
<td>Mean (Std)</td>
<td>Mean (Std)</td>
<td>Mean (Std)</td>
</tr>
<tr>
<td>Bean seed planted (kg) ***</td>
<td>15.71 (16.3)</td>
<td>17.2 (16.4)</td>
<td>13.3 (15.1)</td>
<td>19.1 (20.0)</td>
</tr>
<tr>
<td>Bean harvested (kg/Ha) ***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bush bean plots</td>
<td>1096 (1230)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climbing bean plots</td>
<td>1323 (1548)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Estimating welfare effects of climbing bean adoption
Methodology—Stepwise error correction IV approach

• First step, estimate the climbing bean adoption intensity

\[ D_i = \varphi_k H_{ik} + \tau_i \]

• \( D_i \) = quantity of climbing bean seed used in study season
• \( H_{ik} \) = observable variables that influence the extent of adoption
• \( \tau_i \) = unobservable factors in the model.
  o Tobit model for econometric estimation
  o Same explanatory + instrumental variables as in case of ESR used
  o 1st step, we derive residuals used to correct for endogeneity of adoption in second step
  o Instrumental variables: % HH in village grew climbing a season prior to the survey and population density
Welfare estimation---

• In the second step, welfare outcome

\[ Y_{i\eta} = \gamma_0 + \gamma_i \Omega_i + \psi D_i + \hat{e} + \omega_i \]

- \( \Omega_i \) = household specific exogenous variables
- \( \omega_i \) = random unobserved variable

• Different estimators used for welfare equation:
  • Per capita consumption expenditure—OLS
  • Poverty head count—Probit.
  • Poverty gap—Fractional response probit (Papke and Wooldridge, 1996).
  • Per capita bean consumption (kg)—Tobit model
<table>
<thead>
<tr>
<th>Variables</th>
<th>Log (per capita consumption exp.)</th>
<th>Per capita bean consumption (kg)</th>
<th>Food security (1/0)</th>
<th>Poverty head count (1/0)</th>
<th>Poverty gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kg -climbing bean planted</td>
<td>Coef. 0.009*</td>
<td>dy/dx 0.501***</td>
<td>dy/dx 0.011**</td>
<td>dy/dx -0.006</td>
<td>Coef. -0.026*</td>
</tr>
<tr>
<td>Dependency ratio</td>
<td>-0.309***</td>
<td>-4.651***</td>
<td>0.027</td>
<td>0.313***</td>
<td>0.856***</td>
</tr>
<tr>
<td>Gender of HH head</td>
<td>-0.116**</td>
<td>-1.467</td>
<td>0.028</td>
<td>0.063</td>
<td>0.357**</td>
</tr>
<tr>
<td>Log (Age of HH head)</td>
<td>-0.06</td>
<td>-0.24</td>
<td>-0.1</td>
<td>0.008</td>
<td>0.149</td>
</tr>
<tr>
<td>Log (Village agricultural wage)</td>
<td>0.521***</td>
<td>0.994</td>
<td>0.346***</td>
<td>-0.441***</td>
<td>-1.411***</td>
</tr>
<tr>
<td>Village access to electricity</td>
<td>-0.03</td>
<td>-1.701*</td>
<td>-0.025</td>
<td>0.022</td>
<td>0.18</td>
</tr>
<tr>
<td>Education of HH head —Primary</td>
<td>0.111**</td>
<td>1.267</td>
<td>-0.009</td>
<td>-0.126**</td>
<td>-0.268*</td>
</tr>
<tr>
<td>Education of HH head —Secondary +</td>
<td>0.337***</td>
<td>-0.087</td>
<td>0.097</td>
<td>-0.216*</td>
<td>-0.967**</td>
</tr>
<tr>
<td>Per capita landholding</td>
<td>0.029</td>
<td>0.105</td>
<td>0.022</td>
<td>-0.056</td>
<td>0.021</td>
</tr>
<tr>
<td>Livestock units</td>
<td>0.053**</td>
<td>-0.161</td>
<td>0.081***</td>
<td>-0.048*</td>
<td>-0.145*</td>
</tr>
<tr>
<td>Agricultural index</td>
<td>0.013</td>
<td>0.378</td>
<td>0.072***</td>
<td>0.004</td>
<td>-0.036</td>
</tr>
<tr>
<td>Plot of medium soil fertility</td>
<td>-0.041</td>
<td>-1.255</td>
<td>-0.097**</td>
<td>0.027</td>
<td>0.088</td>
</tr>
<tr>
<td>Plot of Poor soil fertility</td>
<td>-0.042</td>
<td>-0.76</td>
<td>0.01</td>
<td>0.018</td>
<td>0.122</td>
</tr>
<tr>
<td>Market services</td>
<td>0.122*</td>
<td>2.885**</td>
<td>-0.048</td>
<td>-0.151**</td>
<td>-0.419**</td>
</tr>
<tr>
<td>Distance to main town (12-30 km)</td>
<td>-0.001</td>
<td>-0.103</td>
<td>-0.084</td>
<td>-0.062</td>
<td>-0.154</td>
</tr>
<tr>
<td>Distance to main town (&gt; 30 km)</td>
<td>0.057</td>
<td>1.275</td>
<td>-0.114</td>
<td>-0.057</td>
<td>-0.26</td>
</tr>
<tr>
<td>Type of road to the village</td>
<td>-0.211***</td>
<td>-2.154*</td>
<td>-0.126*</td>
<td>0.068</td>
<td>0.461**</td>
</tr>
<tr>
<td>Agricultural credit</td>
<td>0.131**</td>
<td>-1.518</td>
<td>-0.008</td>
<td>-0.157***</td>
<td>-0.318*</td>
</tr>
<tr>
<td>Soil PH (1=5.5+)</td>
<td>-0.047</td>
<td>-1.52</td>
<td>0.021</td>
<td>0.011</td>
<td>0.091</td>
</tr>
<tr>
<td>Agro-ecological zones 2</td>
<td>-0.426***</td>
<td>-2.886</td>
<td>-0.01</td>
<td>0.295**</td>
<td>1.212***</td>
</tr>
<tr>
<td>Agro-ecological zones 3</td>
<td>-0.086</td>
<td>-0.001</td>
<td>-0.271**</td>
<td>0.081</td>
<td>0.415</td>
</tr>
<tr>
<td>Agro-ecological zones 4</td>
<td>-0.416***</td>
<td>-2.08</td>
<td>-0.246**</td>
<td>0.162</td>
<td>1.170**</td>
</tr>
<tr>
<td>Agro-ecological zones 5</td>
<td>-0.454***</td>
<td>-0.434</td>
<td>-0.307***</td>
<td>0.361***</td>
<td>1.366***</td>
</tr>
<tr>
<td>Agro-ecological zones 6</td>
<td>-0.213**</td>
<td>0.927</td>
<td>-0.083</td>
<td>0.136</td>
<td>0.547</td>
</tr>
<tr>
<td>Agro-ecological zones 7</td>
<td>-0.281</td>
<td>6.969**</td>
<td>-0.017</td>
<td>0.206</td>
<td>0.367</td>
</tr>
<tr>
<td>Agro-ecological zones 8</td>
<td>-0.172</td>
<td>4.963***</td>
<td>-0.144</td>
<td>0.149</td>
<td>0.68</td>
</tr>
<tr>
<td>Agro-ecological zones 9</td>
<td>-0.370***</td>
<td>-0.108</td>
<td>0.032</td>
<td>0.250*</td>
<td>0.992**</td>
</tr>
<tr>
<td>Agro-ecological zones 10</td>
<td>-0.231</td>
<td>13.389***</td>
<td>-0.014</td>
<td>0.222</td>
<td>0.806</td>
</tr>
<tr>
<td>Log (Year spent in the village)</td>
<td>-0.018</td>
<td>0.015</td>
<td>0.019</td>
<td>0.056**</td>
<td>0.067</td>
</tr>
<tr>
<td>Distance to extension (km)</td>
<td>-0.006***</td>
<td>-0.073**</td>
<td>0.004*</td>
<td>0.056*</td>
<td>0.009*</td>
</tr>
<tr>
<td>Number of crops in store (1- 4)</td>
<td>0.143***</td>
<td>2.485***</td>
<td>0.215***</td>
<td>-0.157***</td>
<td>-0.448***</td>
</tr>
<tr>
<td>5 or more</td>
<td>0.488***</td>
<td>7.937**</td>
<td>0.068</td>
<td>-0.224</td>
<td>-1.425**</td>
</tr>
<tr>
<td>Predicted Residuals (1st stage)</td>
<td>Coef. -0.007</td>
<td>dy/dx -0.350***</td>
<td>dy/dx -0.013***</td>
<td>dy/dx 0.006</td>
<td>Coef. 0.027*</td>
</tr>
<tr>
<td>Constant</td>
<td>3.554***</td>
<td>5.72</td>
<td>-4.918**</td>
<td>6.309***</td>
<td>5.417**</td>
</tr>
</tbody>
</table>
Key drivers of climbing bean adoption

- Agro-ecological conditions
  - Soil pH
  - Kg planted: 6.8 kg > on farms where soil pH is equal to or above 5.5 as compared with farms (pH = 4.3 and 5.5).
  - Dummies for agro-ecological zones were also highly significant.

- Market access factors: Urbanity and road infrastructure development
  - Kg planted: ---12 and 30 km from a large town —— is 3.0 higher.
  - Kg planted in villages with poor road networks is 2.7 > higher.
Conclusions

• Climbing bean enhances the welfare of the poor producers
• The contribution is even higher when varieties are improved and newly released
• Future impact assessment research
  • The analysis is based on one season data
  • Further research based on other methods to test the robustness of the results
• Also evaluate its potential impact in other countries (based on randomized control design approaches)
Acknowledgments