Integrated Pest Management (IPM) and its Global Impacts

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Objectives of Presentation

- Define Integrated Pest Management and the nature of its impacts
- Give examples of IPM programs
- Present examples of IPM impacts and how they are measured
Integrated Pest Management (IPM)

- Losses due to pests in major crops estimated at 25-40%
- Chemical pesticides can reduce crop losses but are not completely effective and can cause health and environmental problems.
- IPM is an ecosystem-based strategy that emphasizes preventing pests and their damage through a combining techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after pest monitoring or forecasting indicates a need based on established guidelines. Treatments target only the specific pest organism.
- Examples of IPM tactics: use of resistant varieties, pheromone traps, altered planting dates, sanitation, promoting natural enemy populations, crop rotations, grafting, bio-pesticides, pest-predictive models, and selective use of low-toxicity chemical pesticides when economically damaging pest densities are reached.
Nature of IPM Impacts

- IPM has two primary goals: (1) Reduce crop losses to pests (insects, diseases, weeds, nematodes, vertebrates) so as to generate economic benefits and food security and (2) minimize pesticide use to benefit health and the environment.

- IPM can contribute to those goals at the field, household, and market (local, regional, national, international) levels.

- Impacts may result from IPM packages or from components of packages.
Types of IPM Impacts in Agriculture

- Reduced crop losses
- Increased crop yields
- Reduced production costs
- Increased profits
- Reduced pesticide risk
- Poverty reduction
- Lower food costs and greater food security
- Improved nutrition
- Reduced environmental problems

1 IPM can also be applied in urban settings, schools, parks, etc.
Beneficiaries of IPM

- IPM benefits for producers differ by IPM practice, farm size, land tenure status, gender, location, and income level
- IPM adoption influences the demand for purchased inputs and labor
- Consumers benefit through increased food availability at lower price, safer food, and cleaner environment
Nature of IPM Programs

- United States – Public sector IPM research and extension organized around four regions and most land-grant universities contribute; private sector sells IPM products

- Developing countries – Public IPM research and extension, with NGOs involved in IPM diffusion and a small but growing private sector
The IPM Innovation Lab at Virginia Tech

- USAID funded program that has developed IPM programs in 32 countries (currently working in seven: Nepal, Bangladesh, Cambodia, Ethiopia, Kenya, Tanzania, and Vietnam)

- Most of the research based around multidisciplinary teams that work to institutionalize IPM programs in each country

- Some special projects with two current ones on invasive pests such as the tomato leaf miner *Tuta absoluta*
Typical IPM IL Country Program

- Assists host country partners to conduct adaptive research to tailor new or existing IPM practices and packages (especially for vegetables) to local conditions
- Work with public and private sector partners to diffuse IPM practices and packages to farmers
- Improve human and institutional capacity to develop and diffuse IPM programs & practices in the target countries
- Identify effects of policies and regulations that influence the viability and spread of IPM in the target countries
- Evaluate outcomes and impacts of the IPM program
Measuring IPM Impacts

• IPM impact assessment uses a variety of methods, depending on the types of impacts measured

• Some studies evaluate prospective benefits of IPM; others evaluate practices already adopted; others practices recently released but not yet fully adopted
Example of Evaluation of Prospective Research Benefits: Projected Economic Returns from CIP Potato Research (Net Present Value in Millions US$)

Source: Fuglie, 2010
### Examples of Impacts for specific IPM Practices Developed and Adopted

<table>
<thead>
<tr>
<th>Location and Authors</th>
<th>Crop</th>
<th>IPM Practice(s)</th>
<th>Net Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Saharan Africa, Nweke, 2009</td>
<td>Cassava</td>
<td>Biocontrol</td>
<td>+2.5 tons/hectare and &gt;50% rate of return on investment</td>
</tr>
<tr>
<td>Uganda, Moyo et al, 2007</td>
<td>Peanuts</td>
<td>Virus resistant variety</td>
<td>$36-62 million</td>
</tr>
<tr>
<td>Mali, Nouhoheflin, et al, 2010</td>
<td>Tomato</td>
<td>Cultural</td>
<td>$21-24 million</td>
</tr>
<tr>
<td>Bangladesh, Rakshit, 2008</td>
<td>Cucurbits</td>
<td>Pheromone traps</td>
<td>$3-6 million</td>
</tr>
<tr>
<td>Tunisia, Walker and Fuglie, 2001</td>
<td>Potato</td>
<td>Cultural and Biocontrol</td>
<td>$6 million</td>
</tr>
<tr>
<td>Ecuador, Quishpe, 2001</td>
<td>Potato</td>
<td>Resistant variety</td>
<td>$50 million</td>
</tr>
<tr>
<td>India, Myrick, et al, 2014</td>
<td>Papaya and other crops</td>
<td>Biocontrol</td>
<td>&gt;$300 million</td>
</tr>
<tr>
<td>Philippines, Yarobe et al, 2011</td>
<td>Onions</td>
<td>Cultural and Biocontrol</td>
<td>$174 fewer pesticide expenditures per hectare</td>
</tr>
</tbody>
</table>
Types of Quantitative Impact Assessment Methods Applied

- Economic surplus and benefit cost analysis
- Randomized controlled trials with difference-in-difference analysis
- Instrumental variables and propensity score matching
- Calculation of change in poverty indices
- CV analysis or Choice experiments to assess environmental benefits
Economic surplus analysis

\[ B_t = P_0Q_0K(1+.5K\frac{en}{e+n}) = \]

Where: (1) \( K = \frac{(a-c)}{a} \) reflects yield and cost changes, technology adoption, probability of success, and (2) \( e \) and \( n \) = supply and demand elasticities
Productivity or Income Impacts

\[ \Delta TS = + \]
\[ \Delta CS = + \]
\[ \Delta PS = - \]
It is All About Measuring $K$

$$K_t = \frac{(E(Y)/\varepsilon) - (E(C)/(1+E(Y)))}{A_t(1-d)^t}$$

$K_t = \text{Per unit cost reduction}$

$E(Y) = \text{proportionate yield increase per ha for adopters}$

$\varepsilon = \text{the price elasticity of supply}$

$E(C) = \text{the proportionate variable input cost change per hectare}$

$A = \text{proportion of the area affected by the technology}$

$d = \text{the technology depreciation rate}$
Approaches for estimating K

• For specific technologies, obtain K from:
  • Expert opinions of scientists and others
  • Input and yield data from biological field experiments in budgets combined with adoption data from surveys
  • Farm-level survey data in regression-based analyses (e.g., instrumental variables, propensity score matching, double difference)
  • Randomized controlled trials (RCTs); villages and farmers are randomized with treated (receives technology) and untreated groups
Example of Economic Surplus Analysis of a Biocontrol Program

**Net economic benefits of bio-control of papaya mealybug in Southern India**

<table>
<thead>
<tr>
<th>Crop</th>
<th>First year benefit (US$) (ooo$s)</th>
<th>Net present value (US$) over 5 years (ooo$s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papaya</td>
<td>14,427</td>
<td>62,514</td>
</tr>
<tr>
<td>Mulberry</td>
<td>27,924</td>
<td>120,928</td>
</tr>
<tr>
<td>Cassava</td>
<td>221,937</td>
<td>960,737</td>
</tr>
<tr>
<td>Tomato</td>
<td>27,553</td>
<td>119,374</td>
</tr>
<tr>
<td>Eggplant</td>
<td>17,745</td>
<td>76,877</td>
</tr>
<tr>
<td>Total</td>
<td>309,586</td>
<td>1,340,430</td>
</tr>
</tbody>
</table>
Example of Poverty Impact Assessment (Moyo et al. 2007)

- Example: Groundnut Rosette virus resistance in Uganda
  - Total economic benefits estimated ($36-62 million) and combined with household survey data to calculate poverty reduction
  - By projecting who adopted a virus-resistant variety, it was estimated that poverty in one peanut growing region was reduced between .5% and 5%.
Poverty Impacts

- Income gains can be estimated, adoption assessed, and change in poverty rate calculated using an index such as Foster Greer, Thorbecke:

\[
P_\alpha = \frac{1}{Pop} \sum_{i=1}^{N} \left[ \frac{z - y_i}{z} \right]^\alpha
\]

- where \( n \) = total number of households; \( q \) = number of poor households; \( y_i \) = income or expenditure of the \( i \)th poor household; \( z \) = poverty line and \( \alpha \) = poverty proportion, depth, severity (\( \alpha = 0 \), \( \alpha = 1 \), \( \alpha = 2 \))

- FGT index is complementary with RCTs, IVs, economic surplus analyses, and other impact assessment methods.
c) Environmental Impacts

- Multiple methods for assessing bio-physical (RCT, IV) and economic values (CV, Choice Experiment, Benefit Transfer)
  - Assess research-induced biophysical changes first
  - Value non-market benefits
Example of Environmental Benefits Assessment

- Cuyno et al (2001) assessed environmental/health benefits of onion IPM in six villages in the Philippines
  - Growers surveyed about IPM adoption and willingness to pay for pesticide risk reduction
  - Risks assigned to specific pesticides for five health/environmental categories and pesticide reduction measured for IPM program
  - Environmental benefits of onion IPM program estimated (using CV analysis) at $150,000 per year for the 4600 local residents in the villages
Example of Measuring Impact of IPM on Pesticide use

- Yarobe et al (2011) sampled participants and non-participants in onion IPM training and assessed impacts of the training on pesticide costs
  - Sampled 200 growers, 69 of whom had IPM training
  - Controlled for fact that participants were not randomly selected for IPM training using instrumental variables
  - Participants reduced pesticide costs by $174 per hectare
Closing Thoughts

• IPM is pro-poor with emphasis on reducing crop losses, minimizing costs, and helping to reduce food prices.

• IPM research and diffusion approaches must emphasize cost-effective delivery to the masses.

• IPM education must convince farmers and policy makers that non-pesticide practices are more profitable, less risky, and more sustainable than most pesticides being promoted.

• Invasive pests and pest resistance continually develop so task is never complete. More than a third of all agricultural research just keeps yields where they are, as opposed to declining.
Thank You