Precision Pest Management Strategies for Cowpea Farmers in West Africa: *a Proof of Concept*

Cynthia Donovan, Michael Agyekum, Barry Pittendrigh,

Manuele Tamò, and Eustache Biaou

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Department of Agricultural, Food and Resource Economics, Michigan State University
Department of Entomology, Michigan State University
Benin Research Station, International Institute of Tropical Agriculture
Institut National des Recherches Agricoles du Benin (INRAB), Benin

Why Cowpeas?

- Food security crop & income crop for smallholder farmers in West Africa: 10M ha & 5M MT produced
- Cowpeas is one of only four grain legumes in your strategy
- Genetic gains but what about the agronomic gains and research gaps?
- Insect pests are the greatest source of yield loss (50-80%)
- Currently, farmers use highly toxic synthetic pesticides to fight the pests

- There are options to pest control!

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Integrated Pest Management (IPM)

Preventive interventions

Improved plant resistance to pests

- Improved varieties (conventional breeding)
- Transgenics (Bt-cowpea)

Improved ecosystems services

- Biological control
- Ecological engineering

Curative interventions

Application of pest-control products

- Bio-pesticides
- Semio-chemicals (attractants, repellants)
- Synthetic insecticides (last resort, targeted)

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Presentation

1. Technology development and validation: biological control options
2. Technology delivery systems for low literacy farmers: Prototype Expert System (the brain) and Farmer Application (the communicator)
3. Technology evaluation: Does it respond to farmer needs? (profitability, etc.) Is it scalable? Impact if scaled

Collaboration over 10 years, including ….

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What is Biological Control? (Cats & Rats!)

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One of the most devastating insect pests of cowpea in Africa: the legume pod borer, *Maruca vitrata*

Attacks flowers and pods of various legumes, up to 80% yield loss, farmers resort to inappropriate pesticide applications

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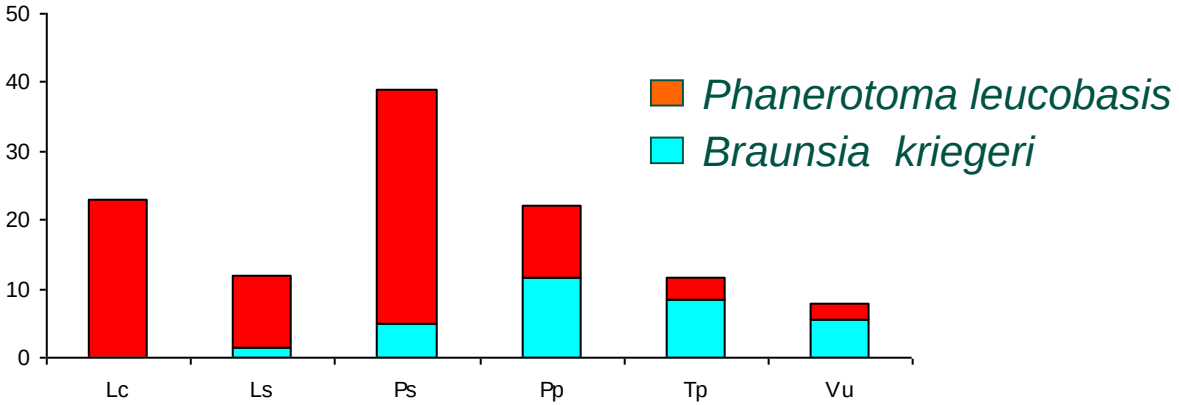
Biodiversity studies

Locally available natural enemies of *Maruca vitrata* in West Africa



Lc: *Lonchocarpus cyanescens*

Ls: *Lonchocarpus sericeus*

Ps: *Pterocarpus santalinoides*

Pp: *Pueraria phaseoloides*

Tp: *Tephrosia plathycarpa*

Vu: *Vigna unguiculata* (cowpea)

Non-host specific parasitoids, low and insufficient parasitism rates

Arodokoun *et al,* 2006

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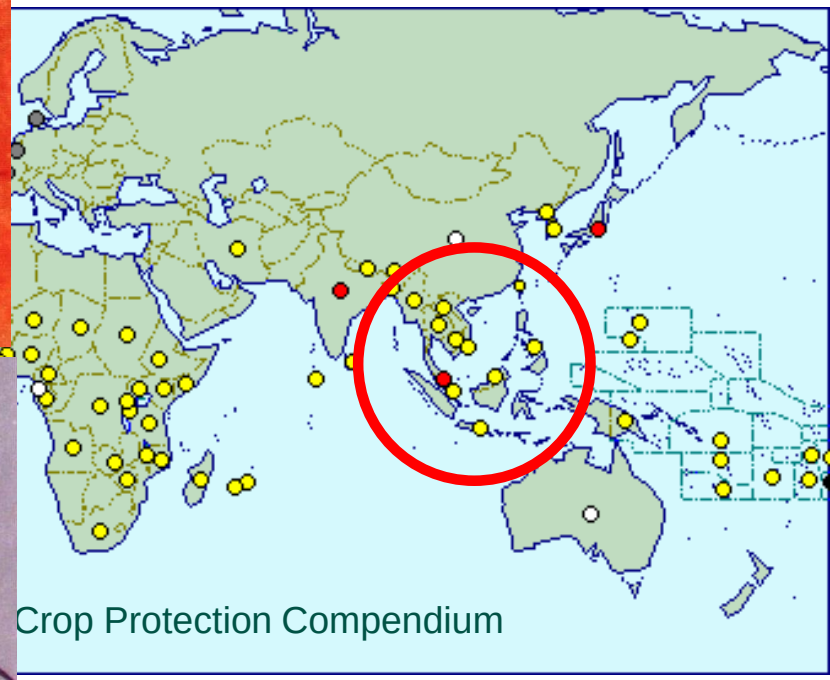
What's about the origin of *M. vitrata*?


Apanteles taragamae


Dolichogenidea sp.


Triclistus sp.


Trichomma sp.



Evidence of South Asian origin supported by latest population genetic studies (Periasamy et al, 2015)

Much larger diversity of co-evolved natural enemies that need to be assessed for their performance using a 'biocontrol pipeline' approach

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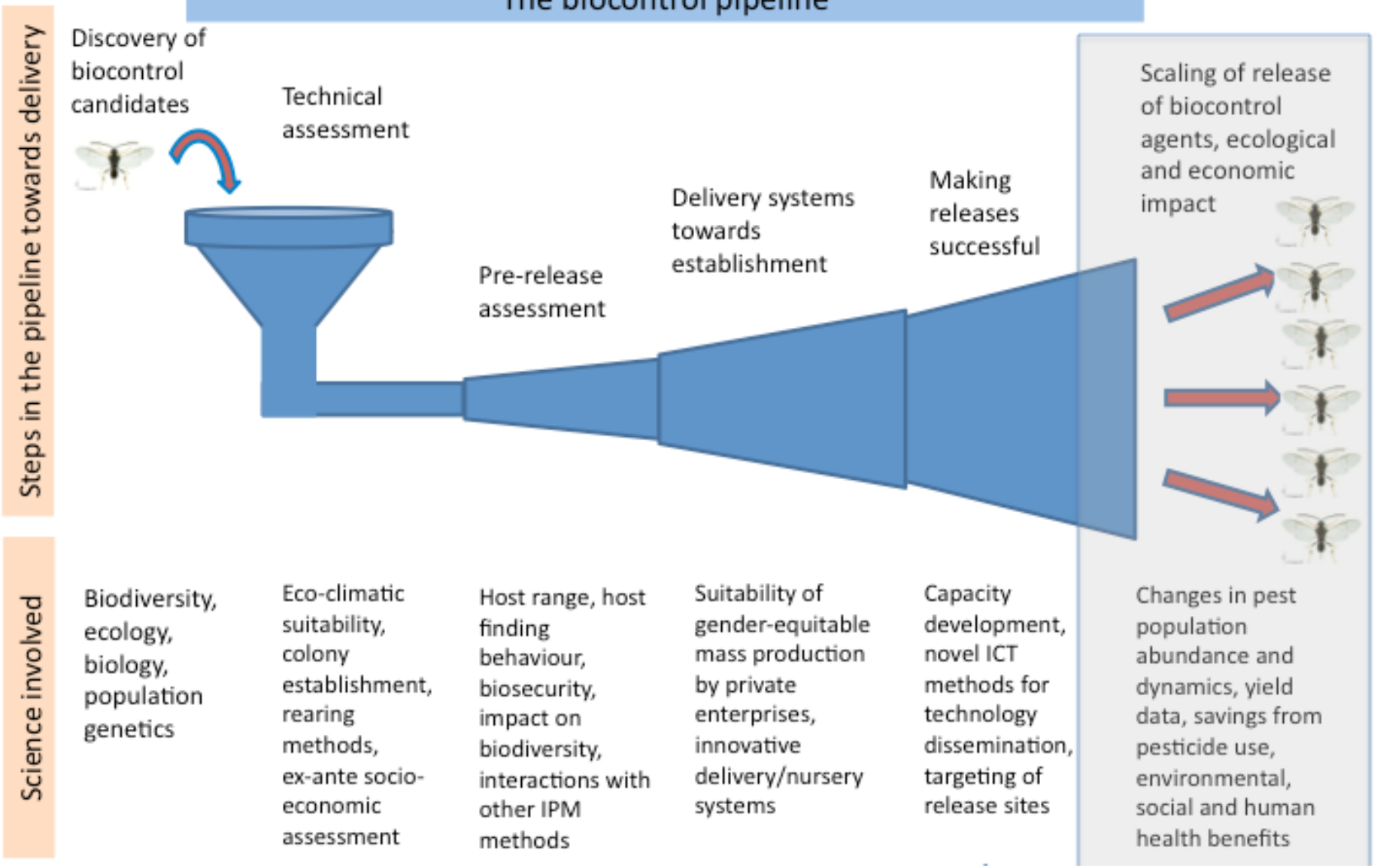
The biocontrol pipeline



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How to feed the pipeline: novel biocontrol agents from the area of origin in Asia

After 2 years of confined testing: first experimental releases of the parasitic wasps (parasitoids) *Therophilus javanus* and *Phanerotoma syleptae*

Pre-release sensitization campaign at each of the release sites

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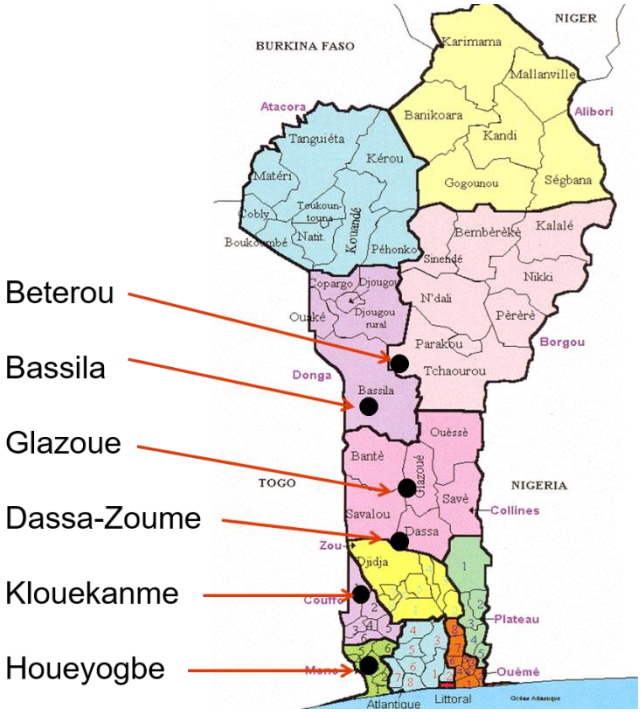
Release sites



Released so far:

32’000 *Therophilus javanus*
17’000 *Phanerotoma syleptae*

Next steps and expected impact:

- Scaling out biocontrol approach to all major cowpea producing countries in West Africa
- Released parasitoids get established and control the pod borer on both natural vegetation and legume crops
- Overall *M. vitrata* population reduction of 40-60% depending on agro-ecological region

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NO SILVER BULLET APPROACH, PLEASE !

There is no ‘silver bullet’ approach in IPM, all compatible technologies have to work together and **in synergy**

IPM = biocontrol + bio-pesticides + resistant varieties (including Bt-cowpea)

Neem oil made in Benin

Pod borer specific virus

Long history of product development, can be produced locally in West Africa

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BUT:

Such an IPM approach is knowledge intensive: IPM is **BY** farmers and not **FOR** farmers

IPM = **farmer knowledge** + biocontrol + bio-pesticides + resistant varieties

How to make sure our cowpea farmer can make informed decisions about pest management to be implemented in her own field?

Farmer knowledge = understanding pest problems + customized solutions in real time

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Technology delivery systems for low literacy farmers

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Automating IPM

- An App in farmers' local languages and in a format they can understand
- Prototype uses Android smart phones with link to the internet
- Collection of data from the field and delivery of solutions in real time
- Interlinked with an analysis system that delivers precision solutions (both in time and location)

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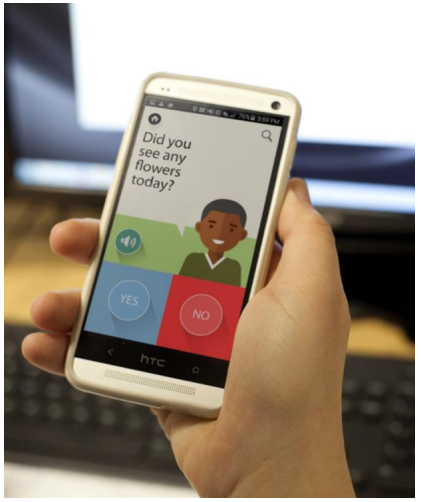
Insect survey data

Climate Data

GIS Data

Expert System

Expert User Interface



Farmer App

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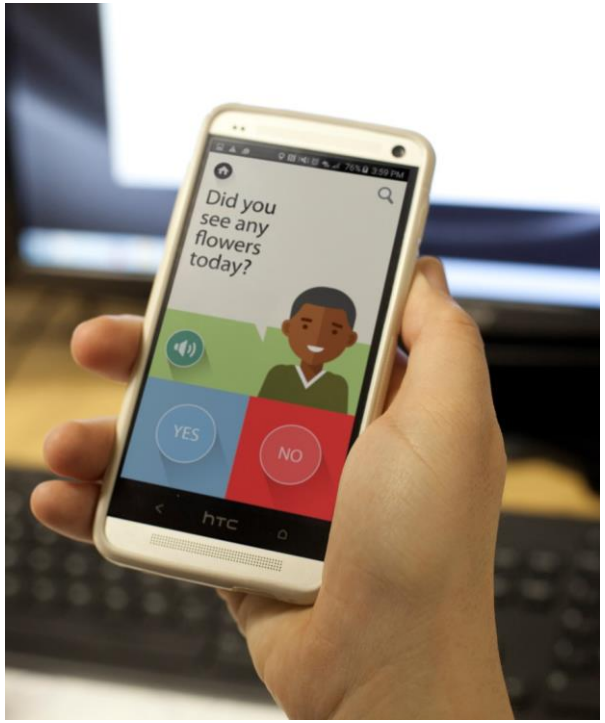
Approach

- Farmer App interfaces with an Expert System
  - Guides farmers to scout for pests
  - Delivers appropriate solutions in real time
  - In their own languages
- An interlinked community
  - Where researcher and farmer data are collected



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Farmer App – Main Features

- Warn farmers when pests are in their area
- Gives farmers a chance to respond
- Teach farmers proper scouting techniques
- Teach farmers proper prevention/response techniques
- Delivers education and instructions in their local languages
  - Easy to understand, audible, animated format
  - Intended for low-literate farmers
  - Can be placed in any language
- Decision tree of when and where to employ a pest control solution
- Interface with Expert System

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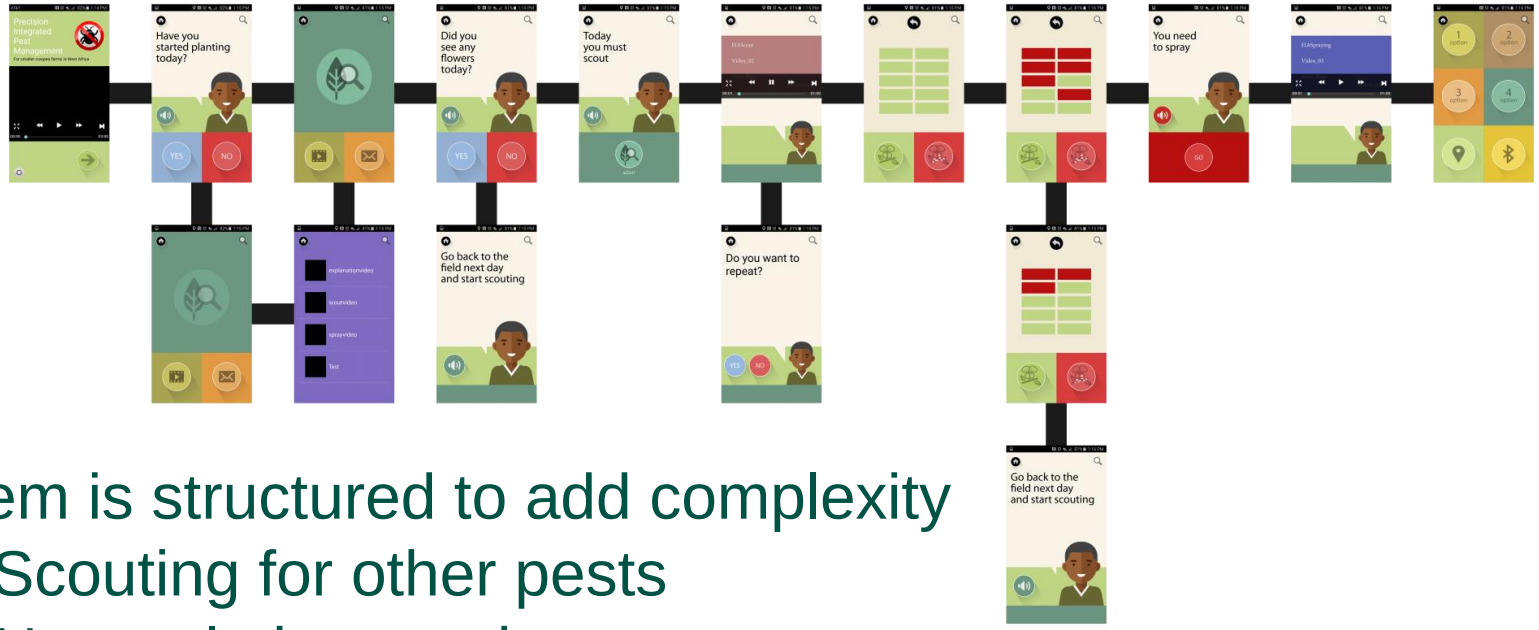
Farmer App – Decision Tree



System is structured to add complexity

- Scouting for other pests
- New solutions to those pests
- Local language

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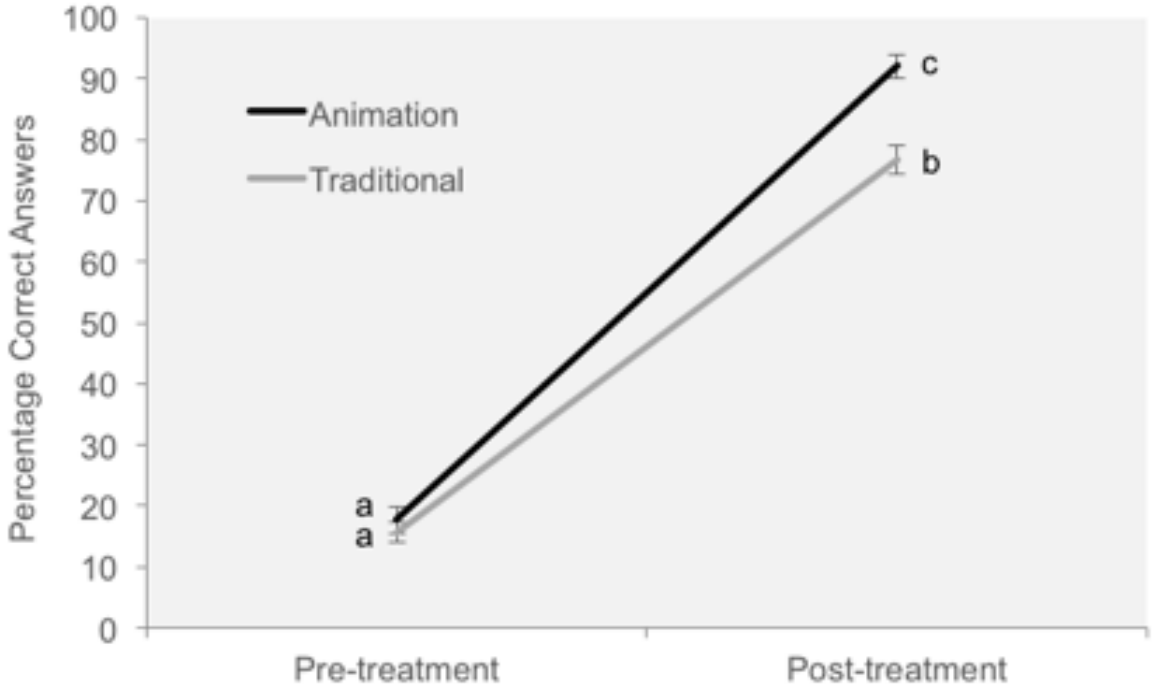
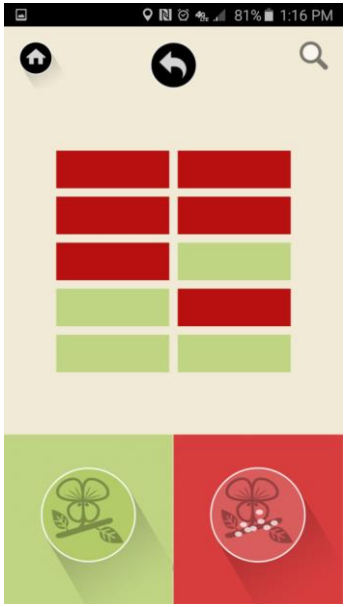
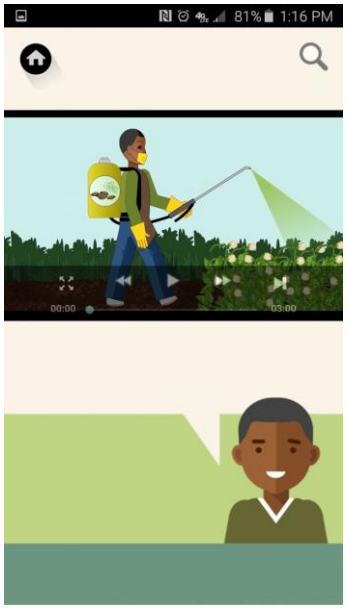
Farmer App

- Easy to follow interface for low literate farmers
- Solutions for low literate farmers







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Expert System – Making of & Technical Details

- The Expert System
- System that takes in outside data, as well as data from the Farmer App to inform it's database
- Pushes out announcements and warnings to any Farmer App user based on data collected, time and location
  - Open Data Kit based
  - GPS coordinates of the Farmer App, and retrieve GIS and weather data Models determine best intervention for farmer, farmer gives feedback and system learns

Expert System – Making of & Technical Details

12+ data parameters that are collected and used by the Expert System:

"*Recipes*" can be created for localized recommendations (type, timing)

Pushed to the Farmer App

Farmer verifies validity of recommendation

System learns to refine recommendation

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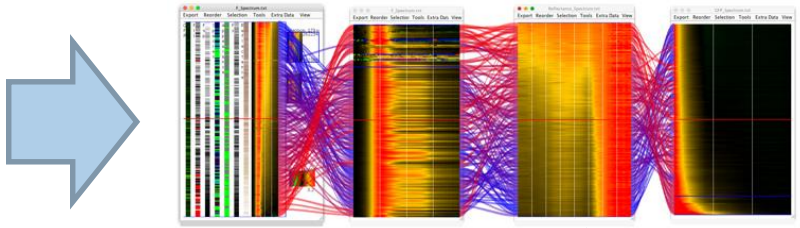
Expert System – Making of & Technical Details



Big data (machine learning)

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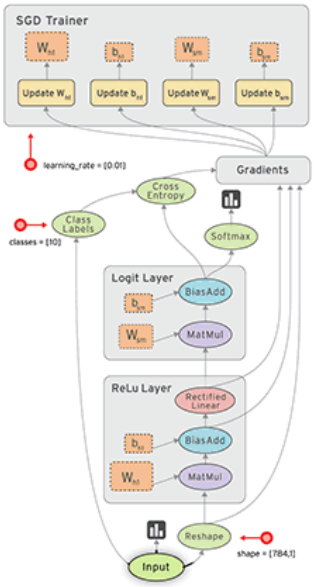

Deep learning algorithm.

Immediate, actionable feedback

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Summation

- Prototype Farmer App developed and being field tested by IITA
- Initial Expert System completed
- Modeling for next complexity level of Expert System in next step project
- Road map for complete development of Farmer App and Expert System for all pests of cowpea and other crops

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Technology Evaluation:

Economics of the novel IPM Strategy in Benin

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Objectives

- Determine preferences for IPM (biocontrol + neem oil + virus) relative to chemical method
- Understand factors influencing decision to switch pest control strategies
- Analyze awareness of health and environmental effects of chemical methods
- Estimate potential impact of IPM on farm income

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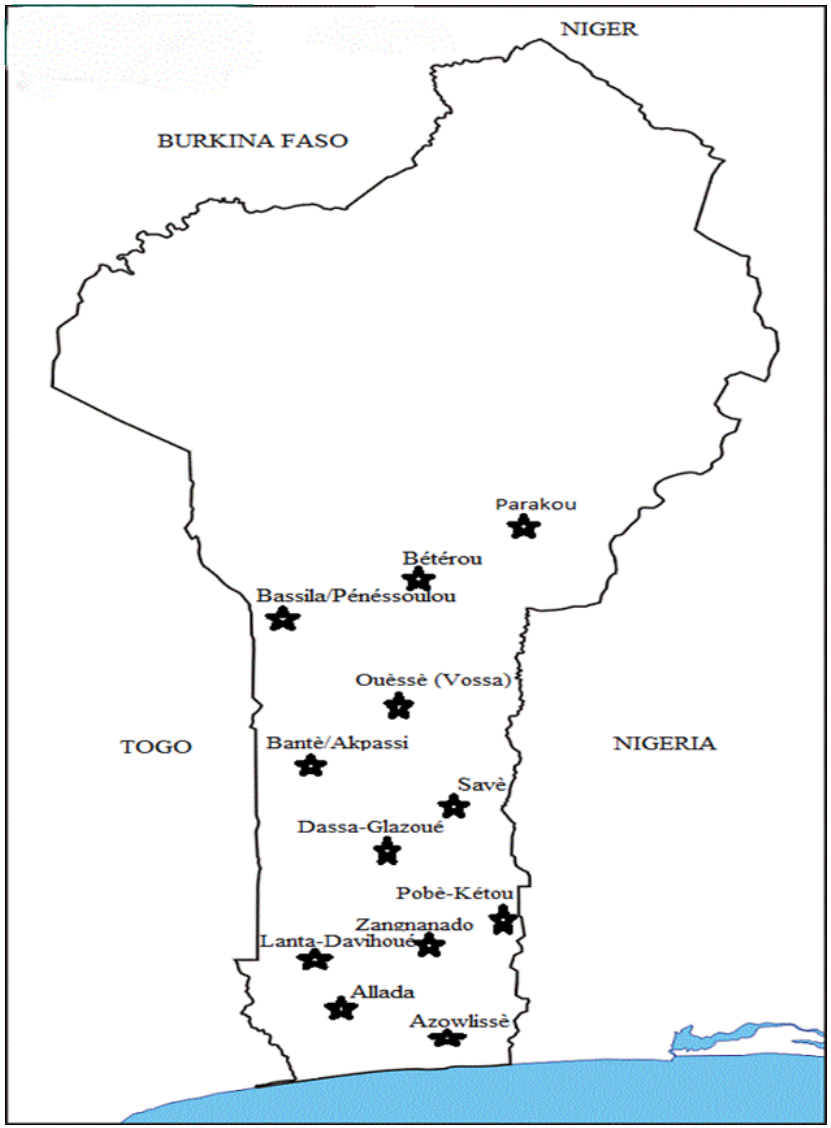
Study Areas

- Benin stratified into 3 zones; North to South
- 12 study areas, 4 per zone (map)
- 2 randomly selected villages per study area
- Sample size of 505 households
- Face-to-face interviews using tablets with ODK App

Map of Benin Showing Study Areas



Source: Biocontrol Unit, IITA-Benin, 2015

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Table 1. Pest management characteristics in Benin

Characteristics	%
Apply chemical pesticides to cowpeas	88
Believe pesticides are harmful to people	93
Knows color label for highly toxic pesticides	11
Use face/nose mask to apply pesticides	24
Skin problems after spraying	73
Eye irritation after spraying	57
Awareness of beneficial insects	9

Source: Survey Data, 2015.

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Choice Experiment (Bio or Chem?)

- Key attributes of pest control identified; cost, yield loss, labor needs
- Scenarios of biocontrol generated, and farmers randomly assigned one
- Farmer's own chemical method used as alternative
- We estimate probability of choosing biocontrol strategy

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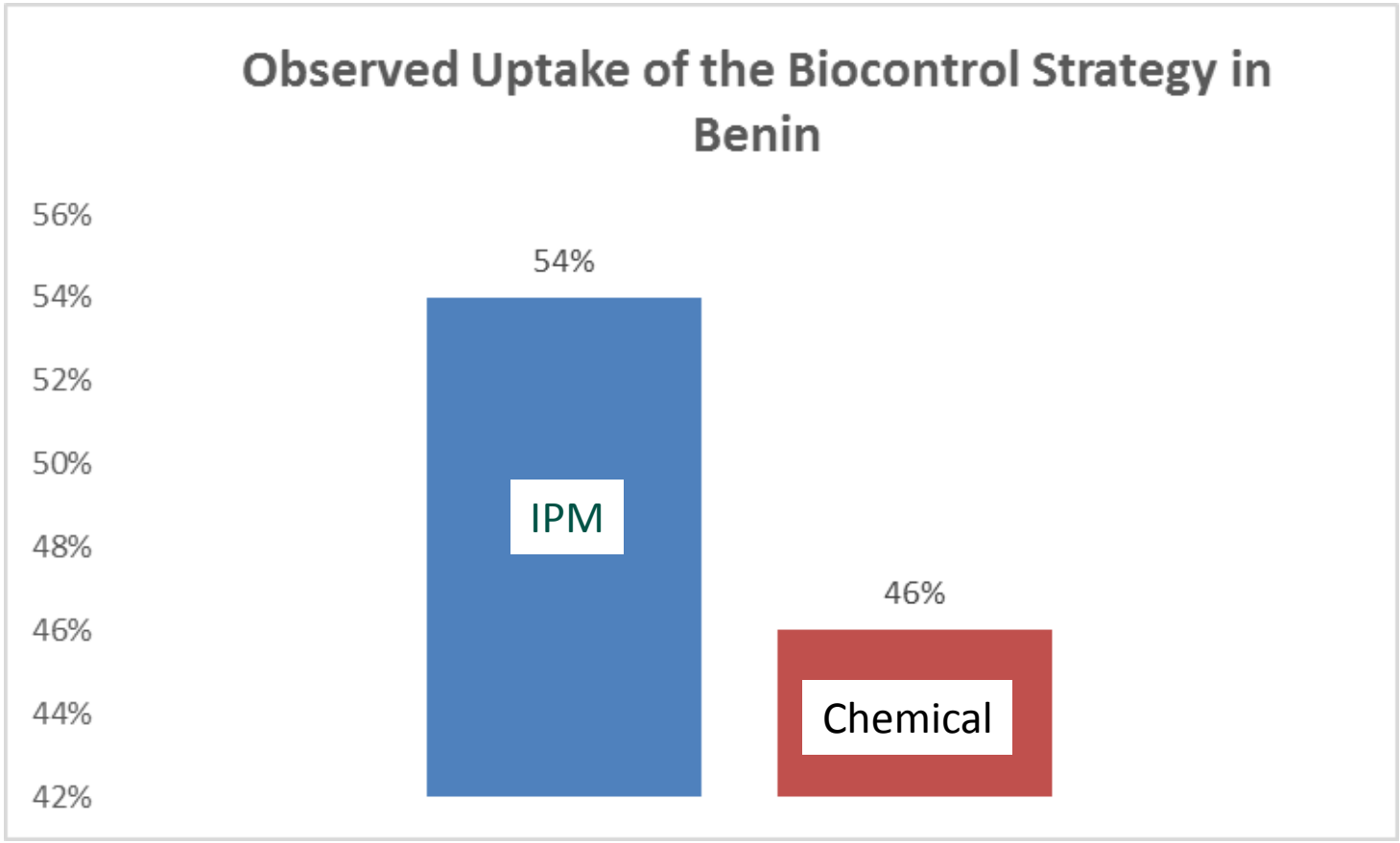

This is based on conservative assumptions of cost and efficacy of IPM strategies.

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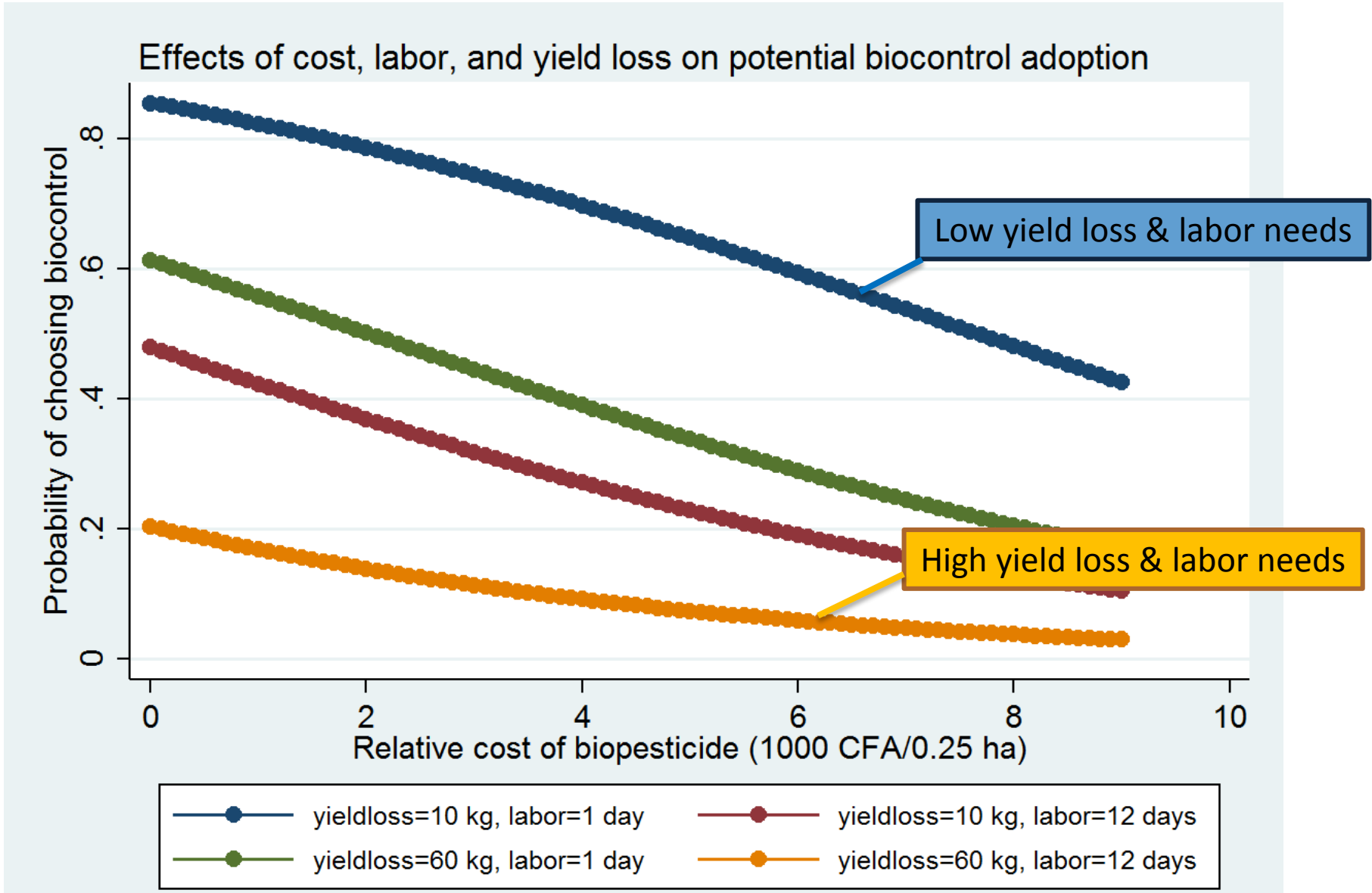

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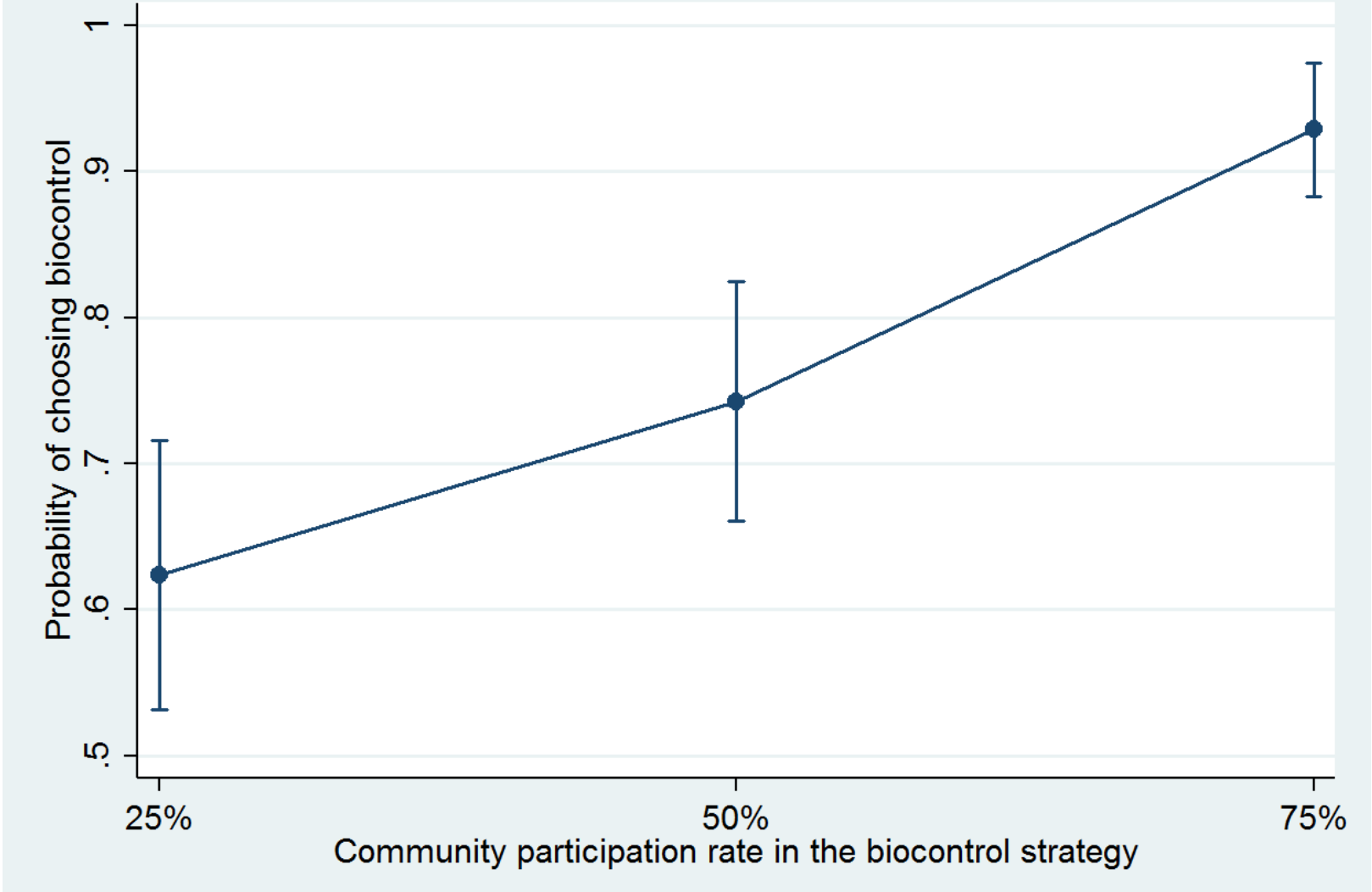

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Biocontrol Impact on Farm-level Income

Enterprise and partial-budget analysis show that:

- Chemical control forms **12% of production costs**
- Existing pest control methods produce net income of CFA 44K or US$ 70 per ha
- Biocontrol **doubles net farm income** due to expected increase in productivity

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Concluding statements

- **High expense on chemicals** unsustainable for resource-poor farmers
- **Farmers aware of health hazards** from chemicals; strong need for alternative pest management strategies
- Control methods with **lower input cost, lower labor needs, and lower yield loss** are preferred
- **IPM preferences are fairly uniform**; mass education strategies could be leveraged for promotion across farming communities
- The IPM strategy with cowpeas has **high potential to increase food and income security** for farm households

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Next steps

- Market-level analysis evaluating impact of IPM strategies on producer and consumer prices
- Economic analysis of health and environmental impacts
- Financial analysis of biopesticide production and value chain development in Benin and the region

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Wrapping it up

- Expand Expert System and Farmer App
- Scale out the IPM approach for Maruca vitrata and expand to other cowpea pests
- Work with business models for greater availability of biopesticides (including neem, virus); value chain analysis with income opps for youth, women
- Track farmers and adoption, continue to get feedback on the training and knowledge development
- Incorporate health and environmental effects into economic analysis
- Reinforce partnerships for long term system sustainability

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Acknowledgment

Opinions expressed in this document are those of the authors and do not necessarily represent BMGF, MSU, IITA, and INRAB.