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Biotech cotton, yield improvement and impacts on global biotechnology policy

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Outline

- USAID Biotechnology
- Current Status & Impact of Biotech Cotton
- Effects on yield/pesticide use
- Country Examples
- Regulatory Systems
- Pipeline technologies

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80+ Missions
8500 Employees (including FSN, PSC)
FY10 Ag R&D ~ $70M USD

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USAID Biotechnology and Biosafety Program Goals

- Increase agricultural productivity and farmer incomes
- Enhance environmental sustainability of agriculture
- Build technical capacity for agriculture R&D
- Create enabling policy environment for biotechnology
- Use biotechnology to address problems conventional breeding is unable to solve

One small component of USAID Agriculture Program

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Product Development Pathway

Source: ABSPII

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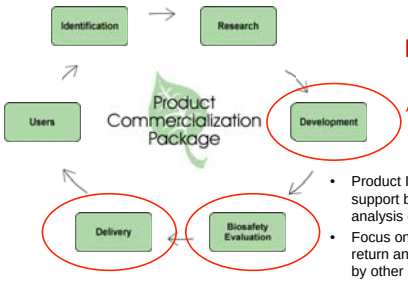
Product Development Pathway



- Product Identification & USAID support based on *ex ante* analysis of target crop
- Focus on crops with high rate of return and not being developed by other means

Source: ABSPII

USAID Biotechnology Program Models

University Managed

ABSP - Mich. State University

ABSPII – Cornell University

CGIAR

-Cereal Systems Initiative for S. Asia

-South Asia Biosafety Program

-Program for Biosafety Systems

Foundations/Direct Support

Donald Danforth Plant Science Center

African Agricultural Technology Foundation

Private Companies

Ceres

Arcadia

7

Genetic Engineering of African Staple Crops

Support National Agricultural Research Stations linkages to develop new varieties not feasible with conventional breeding

Cassava Resistant to mosaic disease in E. Africa

Source: Chris Rey, University of the Witwatersrand, South Africa

Source: Agricultural Research Council, S. Africa

Insect resistant potato in S. Africa

Insect resistant cowpea in Nigeria

Source: Larry Beach

Banana resistant to black sigatoka disease in E. Africa

Source: Larry Beach

Enhanced Cereal Crops in South Asia

- EGAT supports several program in S. Asia emphasizing
  - Drought tolerance
  - Saline soil and salt water tolerant
  - Nitrogen use efficiency to reduce fertilizer need/use
  - Heat tolerance
- Addresses major emerging challenges
  - Water availability, climate change population pressure, resource use
- Potential for enormous impact
  - Food security, income generation, environmental impact
- Working with private sector
  - Pipeline of promising technologies; leverage private sector resources, expertise

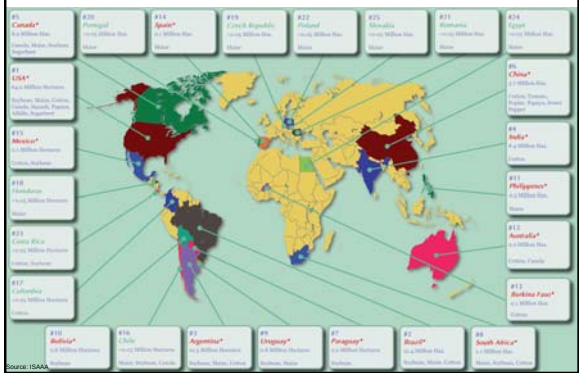
Source: Sahah Anton Chapon

Source: Sahah Anton Chapon

Bt Cotton in USAID Programming

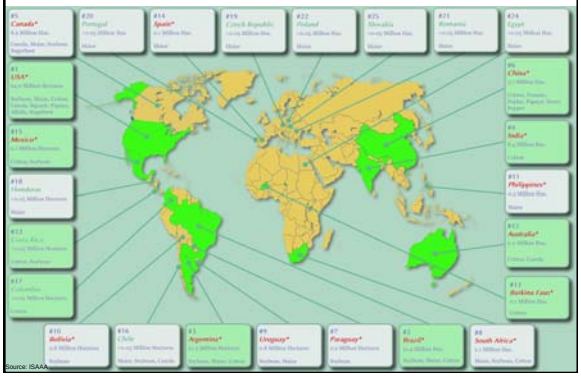
- Private sector opportunity exists in Bt cotton, USAID doesn't directly fund technology development
- USAID works with stakeholders on policy and enabling environment to allow private sector to reach producers
- Specifically with Bt Cotton, support programs that work with regulators and with biotech communications
- Capacity building to promote science based decision making by regulators and policy makers
- Communication programs to educate policy makers and support farmer field visits of Bt Cotton.
- What does global acceptance look like?

Global Biotechnology Adoption



Source: ISAAA

Global Biotech Cotton Adoption



Source: ISAAA

Bt Cotton Adoption

- 16.1 M ha of Biotech Cotton (12% of GE area globally) across 11 countries
- Biotech cotton encompasses >90% of cotton area in US, Australia, S. Africa, >75% of this area double-stacked HT/Bt
- Encompassed > 50% in at least four more countries (India, China, Mexico and Argentina)
- 29 Cotton events approved globally currently, including food and feed.

Trait adoption and market share

Table 2.2 Area of cotton planted, in hectares, by type (and per cent of total cotton area), 2007

Country	Insect-resistant (only) transgenic cotton	Herbicide-resistant (only) transgenic cotton	'Stacked' insect- and herbicide-resistant transgenic cotton	Conventional cotton	Total cotton area (hectares)
China	3,830,000 (69%)	—	—	1,717,000 (31%)	5,547,000
India	6,475,000 (73%)	—	—	2,428,000 (27%)	8,903,000
Argentina[1]	91,000 (22%)	239,000 (57%)	—	86,880 (21%)	416,880
Colombia[1]	19,943 (43%)	458 (1%)	482 (1%)	25,414 (55%)	46,297
Mexico	19,399 (17%)	4239 (4%)	34,981 (32%)	52,395 (47%)	111,014
South Africa[1]	909 (8%)	455 (4%)	9204 (81%)	795 (7%)	11,363
Australia	19,655 (12%)	15,625 (10%)	112,033 (68%)	17,188 (10%)	164,501
USA[1]	27,009 (1%)	827,692 (19%)	3,240,633 (74%)	260,941 (6%)	4,356,275

Source: National statistics and estimates collected by country consultants. (Includes estimates of legal and illegal planting.)

Notes
1 Argentina, Colombia and South Africa are 2006/07 season.
2 USA is for upland cotton only, calculated from data in AMS (Agricultural Marketing Service), 2007. A different set of estimates is provided in NASS (2007).

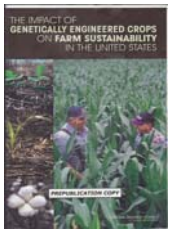
Source: Tripp (2010)

Peer reviewed studies of yield/ pesticide impacts of Bt Cotton

Three reports/reviews released this year synthesizing existing research on Biotech Crops/Biotech Cotton in the U.S. and globally

Tripp et al (2010 – Small holders in developing countries

Peer-reviewed surveys indicate positive impact of commercialized GM crops



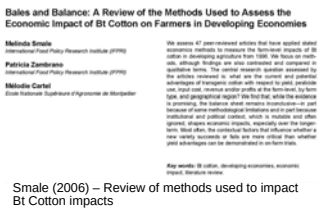
Carpenter et al (2010) - Global Research Summary

National Academies Report (2010) – US Only

Factors affecting Yield Gain

As Bt Cotton is yield *protecting*, many factors affect yield gains observed

- Farming Practices
- Inputs
- Agronomics
- Environment/Climate
- Insect Pressure
- Availability of non-bt controls



Bales and Balance: A Review of the Methods Used to Assess the Economic Impact of Bt Cotton on Farmers in Developing Economies

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We assess 47 peer-reviewed articles that have applied stated economics methods to measure the farm-level impacts of Bt cotton in developing agriculture from 1996. We focus on methods, although findings are also contrasted and compared in qualitative terms. The central research question assessed by the articles reviewed is: what are the current and potential advantages of transgenic cotton with respect to yield, pesticide use, input cost, revenue and/or profits at the farm-level, by farm type, and geographical region? We find that, while the evidence is promising, the balance sheet remains inconclusive—in part because of some methodological limitations and in part because institutional and political context, which is mutable and often ignored, shapes economic impacts, especially over the longer-term. Most often, the contextual factors that influence whether a new variety succeeds or fails are more critical than whether yield advantages can be demonstrated in on-farm trials.

Key words: Bt cotton, developing economies, economic impact, literature review

Smale (2006) – Review of methods used to impact Bt Cotton impacts

Yield gain studies

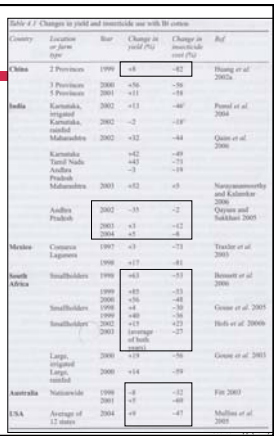
- Studies earlier in adoption to ensure controls available

Show variability of result

Some of highest insecticide savings – China, Mexico.

Some of highest yield gains with Small holders in S. Africa, India

Comprehensive discussion in literature on estimations of variability – some interesting points



Yield gain studies

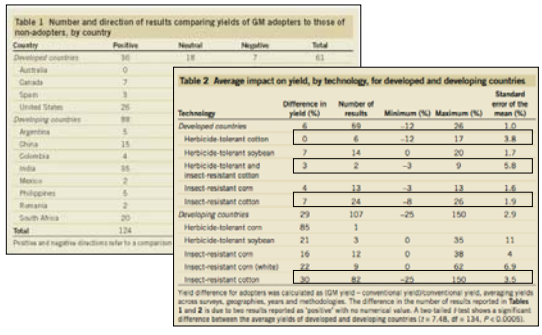


Table 1 Number and direction of results comparing yields of GM adopters to those of non-adopters, by country

Country	Positive	Neutral	Negative	Total
Developed countries	36	18	7	61
Australia	0			
Canada	7			
Spain	3			
United States	26			
Developing countries	88			
Argentina	5			
China	15			
Colombia	4			
India	55			
Mexico	2			
Philippines	5			
Romania	2			
South Africa	20			
Total	124			

Positive and negative directions refer to a comparison

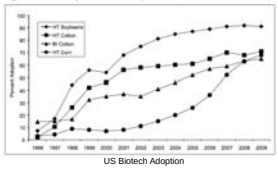
Table 2 Average impact on yield, by technology, for developed and developing countries

Technology	Difference in yield (%)	Number of results	Minimum (%)	Maximum (%)	Standard error of the mean (%)
Developed countries	6	69	-12	26	1.0
Herbicide-tolerant cotton	0	6	-12	17	3.8
Herbicide-tolerant soybean	7	14	0	20	1.7
Herbicide-tolerant and insect-resistant cotton	3	2	-3	9	5.8
Insect-resistant corn	4	13	-3	13	1.6
Insect-resistant cotton	7	24	-8	26	1.9
Developing countries	29	107	-25	150	2.9
Herbicide-tolerant corn	85	1			
Herbicide-tolerant soybean	21	3	0	35	11
Insect-resistant corn	16	12	0	38	4
Insect-resistant corn (white)	22	9	0	62	6.9
Insect-resistant cotton	30	82	-25	150	3.5

Yield difference for adopters was calculated as (GM yield − conventional yield)/conventional yield, averaging yields across surveys, geographies, years and methodologies. The difference in the number of results reported in **Tables 1** and **2** is due to two results reported as 'positive' with no numerical values. A two-tailed *t* test shows a significant difference between the average yields of developed and developing countries ($t = 7.48$, $df = 134$, $P < 0.0005$).

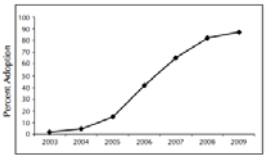
Source: Carpenter (2010)

Real testament to impact – farmer adoption

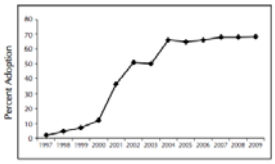


US Biotech Adoption

- Overwhelming acceptance where growers are given market freedom



Bt Cotton Adoption in India



Bt Cotton Adoption in China

Real testament to impact – farmer adoption

Table 2.3 Area in hectares (and per cent of total cotton area) planted with transgenic, insect-resistant cotton, (single trait or stacked), by year

Country	2004	2005	2006	2007
China	3,700,000 (66%)	3,300,000 (65%)	3,500,000 (66%)	3,830,000 (69%)
India	1,307,000 (16%)	3,247,000 (38%)	5,423,000 (65%)	6,475,000 (73%)
Argentina	54,000 (20%)	51,000 (13%)	25,000 (8%)	91,000 (22%)
Colombia	11,436 (17%)	25,910 (35%)	23,691 (42%)	20,883 (45%)
Mexico	65,231 (60%)	79,824 (61%)	54,750 (47%)	58,619 (53%)
South Africa	28,932 (81%)	13,275 (61%)	14,310 (79%)	10,113 (89%)
Australia	58,057 (29%)	214,662 (70%)	247,295 (78%)	131,688 (80%)
USA[1]	2,903,836 (54%)	3,465,461 (61%)	4,019,620 (66%)	3,267,642 (75%)

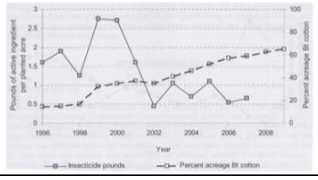
Source: National statistics and estimates collected by country consultants. (Includes estimates of legal and illegal planting.)

Note
1 USA is for upland cotton only, based on data from AMS (Agricultural Marketing Service), various years.

Source: Tripp (2010)

The U.S. Example

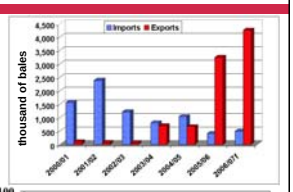
- Introduced in 1996
- Currently, > 90% is Bt, HT or Stacked HT/Bt
- NRC highlights studies reporting yield gains from 8% to 30% in the case of high pest pressure
- Adoption of Bt Cotton has been accompanied with decrease in insecticide
- Developing new refuge strategies / maintaining performance



Source: NRC (2010)

The India Example

- Issues early on with seed supplies, cultivation, and agronomics in some states (Andhra Pradesh, etc)
- Moved beyond hurdles to experience significant gains in adoption/yield
- Currently, 87% is Bt Cotton (8.4M ha) planted by 5.6M farmers
- Moved from import to export, estimated $5.1B gain in first 6 years (ISAAA)
- Currently – maintain efficacy / pest resistance



Source: USDA/FAS

The Burkina Faso Example

- First planting in 2008 – 8,500 ha
- 2009 – Bt Cotton 115,000 ha of 400,000 total ha – 29% adoption in second year up from 8%.
- Good ex-post study needed on economic impacts of Bt cotton in Burkina
- Biotech leader in W. Africa – also involved in AATF rice project

Source: grain.org

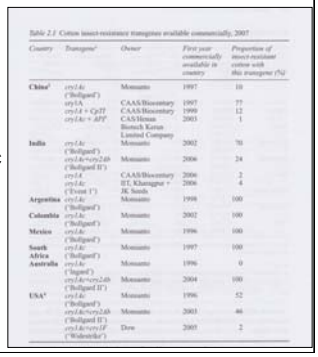
Pipeline Technologies

- Drought, salt tolerant genes
- Nitrogen-Use efficient genes
- Tolerance of new herbicides
- Stacked Traits / Pyramid Bt Genes
- New Refuge strategies

Source: Photoshare

Insect Resistant Cotton Transgenes

- Dominated by private sector – a function of regulatory cost / private sector role in Cotton
- Recently introduced public sector technology in India (2008)
- More streamlined regulatory system = more players in the market



Why not further?

- What has been limiting factors to adoption of Bt Cotton?

Suitable for environment and local pests?

Farmer & Public Acceptance?

Existence of a functional regulatory system?

Importance of a Regulatory System

- Without a functional regulatory system, farmers do not have market freedom and cannot access Bt Cotton
- Bt Cotton and cotton producers have often been the catalyst to promote regulatory system development (Burkina, India) or are currently applying pressure (Tanzania, Ethiopia et al)
- Lack of a functional regulatory system can promote illegal procurement of technologies (likely not optimized for environment, low quality)

Our Biosafety work

Bilateral & Regional Programs in Africa/SE Asia

Regional Biosafety Frameworks

India/Bangladesh Biosafety Programs

Current status of biosafety frameworks

- **Functional** (Burkina Faso, India, South Africa, Philippines)
  - Existing process
  - Commercial biotech crops
  - Always room for improvement
- **Almost there** (Egypt, Kenya, Senegal)
  - Existing frameworks – working on implementation
- **Under development** (Uganda, Malawi, Bangladesh, Nigeria, Ghana)
  - Bills in parliament, drafting regulations
- **Nonexistent** (Benin, Zambia)
  - Moratorium, negative outlooks

What does functional mean?

- Science-based
- Effective, efficient, predictable
- Addresses research, field trials, commercialization, commodity imports
- Clear regulatory authority, without overlapping mandate or gaps in mandate

Biosafety capacity building activities

- **Generic training**
  Wider reach, cost-effective, insufficient depth, leaves questions
- **Training for specific outcomes**
  Resource, time intensive, builds specific skills, confidence
- **Legislation and regulation development**
  Long-term support for document drafting, review, approval
- **Operational and organizational support**
  Help implement systems, formalize processes, timelines
- **Support to product developers**
  Ensure high-quality data, safe products, research partnerships

South Asia Biosafety Program

Challenges of Biosafety Policy

- Slow pace of partner governments and institutions
  - Easier to not make decisions than deal with consequences of decisions
- Few donors fund biotech research
  - USAID only major donor politically able to support biotech
- Delivery of biotech products/hybrids – need to improve seed systems (in general)
- Much anti-biotech activity
  - Greenpeace, FOE, etc…
- Socioeconomic concerns
  - Credible information needs to be widely disseminated

Regional Biosafety Framework

- Take advantage of regional biosafety capacity by pooling technical expertise
- Reduce and share the cost of review across member countries and avoid duplication
- Encourage investment: increase market size for product developers through common standards and reduce uncertainty in product or crop approvals
- Remove trade barriers within an economically integrated region and preempt trade disputes with external trading partners
- Avoid asynchronous approvals, especially across porous borders or common markets

Conclusions?

- Bt Cotton has been widely & quickly accepted where available to growers
- Yield reports are varied, but in general are quite favorable
- Savings on insecticides are also generally favorable.
- In many cases, Bt Cotton is driving demand for biosafety policy development
- Development of sound science based-policies at the national and regional level well help cotton growers access biotech cotton – we hope *USAID* can help!

Thank you

Supplemental Slides

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Global Food and Feed Approval of Insect Resistant and Stacked Insect Resistant/Herbicide Tolerant Cotton

	15985	281-24-236	3006-210-23	31807/31808	COT 102	DAS-21023-5x DAS-24236-5	DAS-21023-5x DAS-24236-5x MON-01445-2	DAS-21023-5x DAS-24236-5x MON 88913	DAS-21023-5x MON-01445-2	MON-15985-7x MON-01445-2	MON-00531-6x Mon- 01445-2	MON 88913	MON- 15985x	MON 531/ 757/ 1076
Argentina										●□				●□
Australia	●				●	●								●□
Brazil														●□
Canada	●□	●□	●□	●										●□
China	●□													●□
Columbia											●□	□		●□
EU	●□									●□	●□			●□
Japan	●□	●	●	●□		●□	●□	●□		●□	●□	●□		●□
Korea	●□					●	●	●		●	●	●		●□
Mexico	●□	●□	●□			●□	●□	●□		●□	●□	●□		●□
Philippines	●□									●□	●□	●□		●□
South Africa	●□										●□	●□		●□
USA	●	●□	●□	●□	●□	●□								●□

● Food □ Feed

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Global Food and Feed Approvals of Herbicide Tolerant Cotton

	19-51A	31807/ 31808	BXN	GHB614	LL Cotton25	MON 1445/ 1698	MON 88913
Argentina						●□	
Australia			●□		●	●	●
Brazil					●□	●□	
Canada		●	●□	●□	●□	●□	●□
China					●□	●□	
Columbia						●□	●□
European Union					●□	●□	
Japan		●□	●□		●□	●□	●□
Korea					●□	●□	●□
Mexico			●□		●□	●□	●□
Philippines						●□	●□
South Africa						●□	●□
USA	●□	●□	●□	●□	●□	●□	●□

● Food □ Feed