



Crop Biotechnology: global economic and environmental impacts 1996-2024



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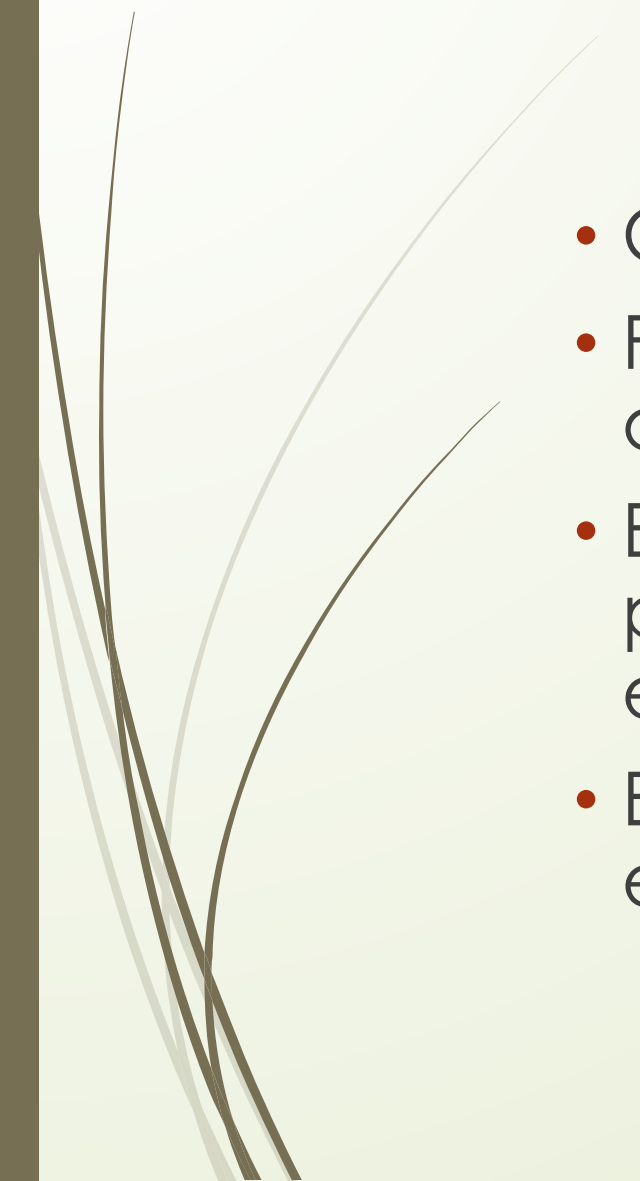


Background

- 16th review of global biotech crop impacts
- Three separate papers (with open access) covering economic and environmental impacts currently in peer review process with journal GM Crops and Food. The environmental impact associated with pesticide use, the environmental impact associated with carbon emissions and the economic impact
- Full report will also be available at www.pgeconomics.co.uk



Coverage

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- Cumulative impact: 1996-2024
 - Farm income and productivity impacts: focuses on farm income, yield, production
 - Environmental impact analysis covering pesticide spray changes and associated environmental impact
 - Environmental impact analysis: greenhouse gas emissions



Methodology



- Use of the considerable peer reviewed impact literature plus own analysis
- Dynamic analysis - uses updated data for each year eg, costs, prices, yields
- Reviews pest and weed control practices, pesticide usage: actual and typical biotech versus conventional treatments
- Use of additional environmental impact indicator – the Environmental Impact Quotient (EIQ) indicator
- Review of carbon impacts – fuel use changes and soil carbon storage



Structure of presentation

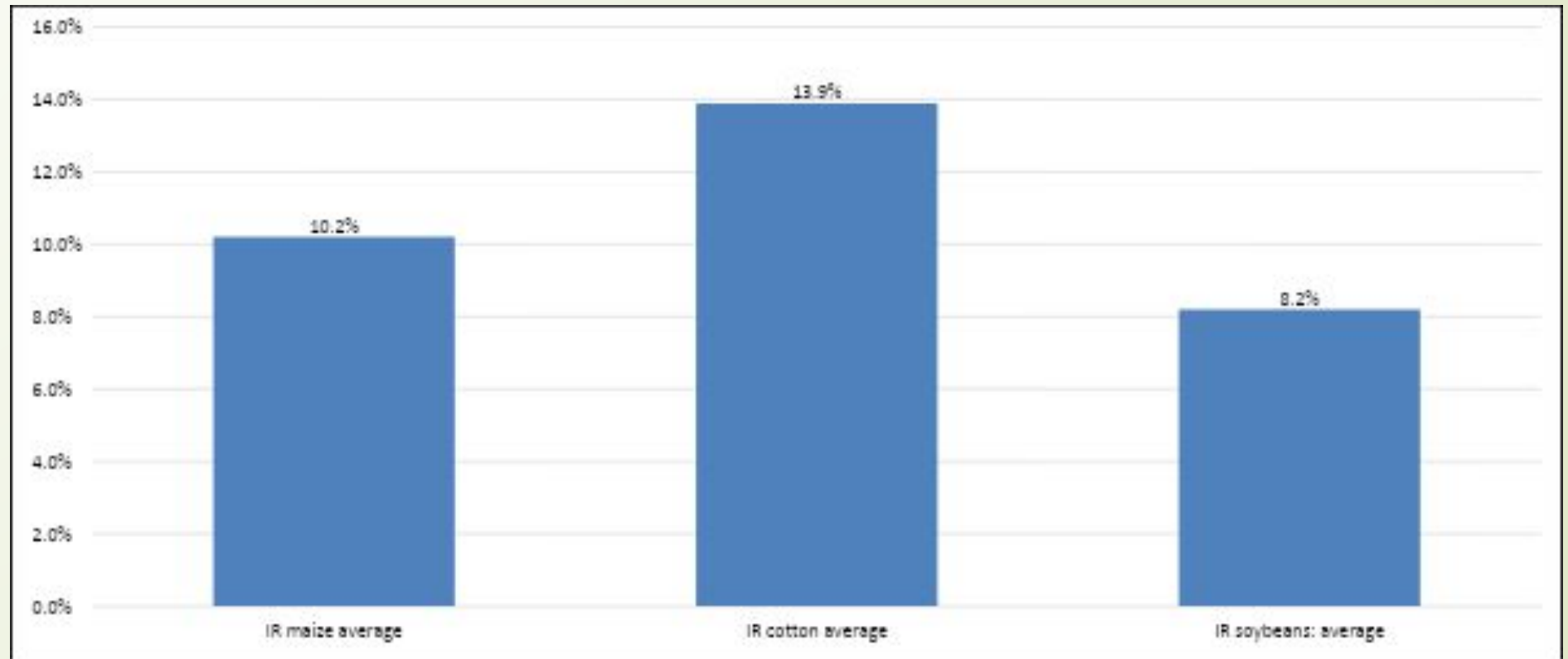
Has crop biotechnology contributed to feeding the world sustainably?

Examined under 3 main themes

- Contribution to global food security and reduced pressure to use new land in agriculture
- Contribution to reducing agriculture's environmental footprint
- Contribution to economic sustainability

Average yield gains 1996-2024: Insect resistant maize, cotton and soybeans

Theme: contribution to global food security and reduced pressure to use new land in agriculture



Note: IR soybeans South America only from 2013

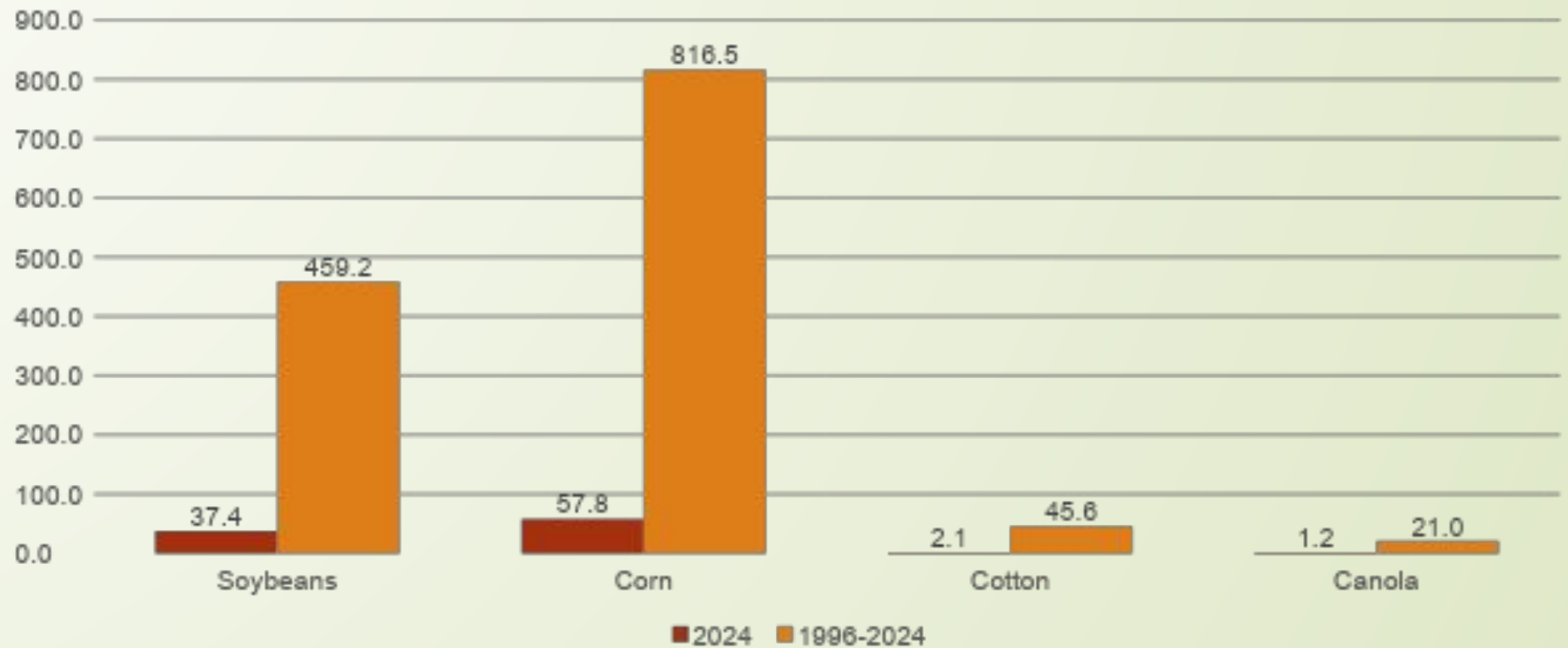
Herbicide tolerant traits: yield and production effects

Theme: contribution to global food security and reduced pressure to use new land in agriculture

	Trait/country	Yield/production effect
	HT soy: Romania and Bolivia	+23% and +15% respectively on yield
	HT soy: 2 nd generation: US and Canada	+9% yield
	HT soy Argentina and Paraguay	Facilitation of 2 nd crop soy after wheat: equal to +25% and +12% respectively to production level
	HT corn: Argentina, Brazil, Philippines and Vietnam	+10%, +3.2%, 5.2% and +5% respectively on yield
	HT cotton: Mexico, Colombia and Brazil	+14%, +3.4% and +1.9% respectively on yield
	HT canola: US, Canada and Australia	+1.9%, +6.2% and +8.5% respectively on yield

Additional crop production arising from positive yield/production effects of biotech traits 1996-2024 (million tonnes)

Theme: contribution to global food security and reduced pressure to use new land in agriculture





Land sparing: additional conventional area required if biotech not used (m ha)

*Theme: contribution to global food security and reduced
pressure to use new land in agriculture*

	2024
Soybeans	12.8
Maize	9.6
Cotton	2.5
Canola	0.6
Total	25.5 equal to combined agricultural area of Philippines and Vietnam

Impact on greenhouse gas emissions

Theme: contribution to reducing agriculture's environmental footprint



Lower GHG emissions:

2 main sources:

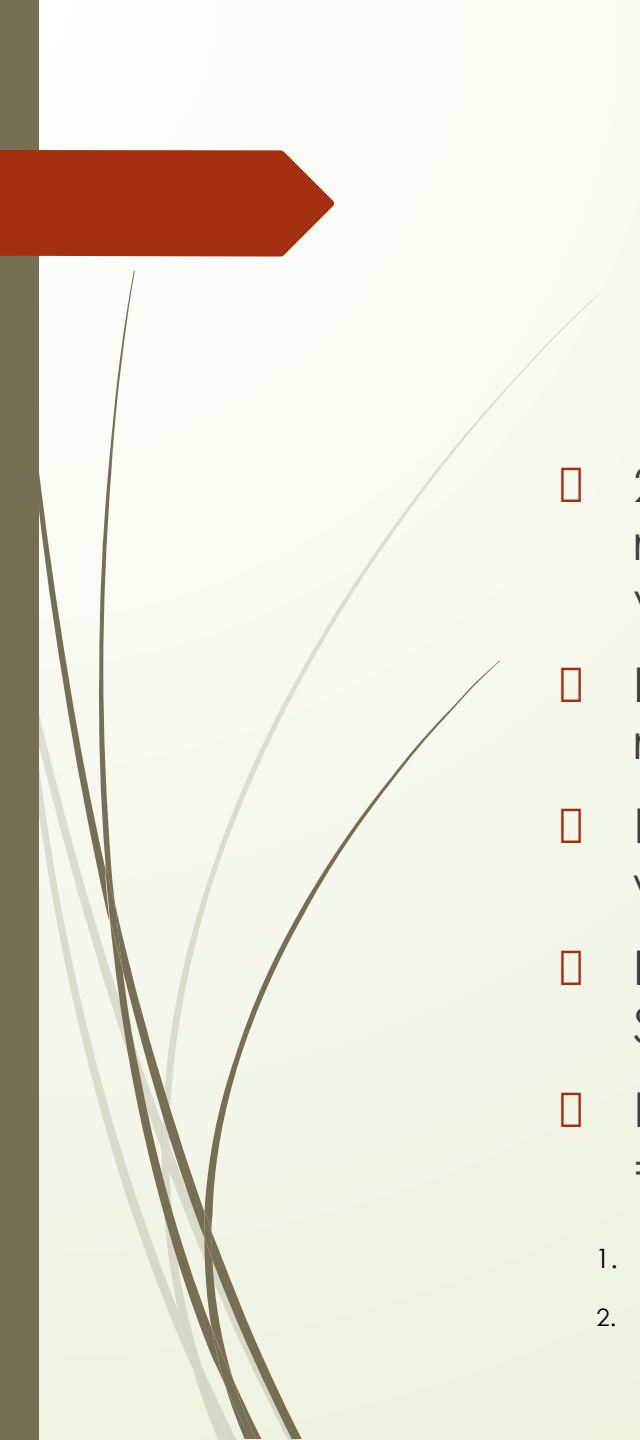
- ❑ Reduced fuel use (less spraying and soil cultivation)
- ❑ HT crops facilitate no till systems = less soil preparation = additional soil carbon storage



Reduced greenhouse gas emissions: fuel savings 1996-2024

Theme: contribution to reducing agriculture's environmental footprint

Savings	Units
Fuel use	-24,932 million litres
Carbon dioxide emission reduction	-66,567 million kg
Cars off road equivalent for one year	-44.1 million



Reduced greenhouse gas emissions: soil carbon storage 1996-2024

Theme: contribution to reducing agriculture's environmental footprint

- 2024 saving: -6,887 million kg soil carbon stored = -25,276 million kg Co₂ not released into atmosphere = equivalent to 16.7 million cars off road for 1 year
- If annual savings aggregated 1996-2024 = 400,854 million kg of Co₂ not released into atmosphere BUT
- Due to some land not staying in permanent no/reduced tillage true savings will be lower
- In US, estimated (1) only 20% of arable land stayed in no till 2012-2016. In South America likely to be higher (2)
- Likely cumulative Co₂ saving in range 80,160 million kg to 320,640 million kg = 53 million to 212 million cars off road for 1 year

1. Source: Claassen R, Bowman M, McFadden J, Smith D and Wallander S. 2018. Tillage intensity and conservation cropping in the United States. EIB-197. [USDA ERS - Tillage Intensity and Conservation Cropping in the United States](#)
2. Based on data of annual estimates of soybean area using no tillage and Argentine no-till farmers association (AAPRESID)



Reduced greenhouse gas emissions: fuel saving and soil carbon storage combined 1996-2024

Theme: contribution to reducing agriculture's environmental footprint

Source	Co2 Saving (million kg)
Reduced fuel use	66,567
Soil carbon storage	80,160-320,640
Total	146,727-387,207 = equivalent of 97 million to 256 million cars off road for 1 year



Impact on pesticide use

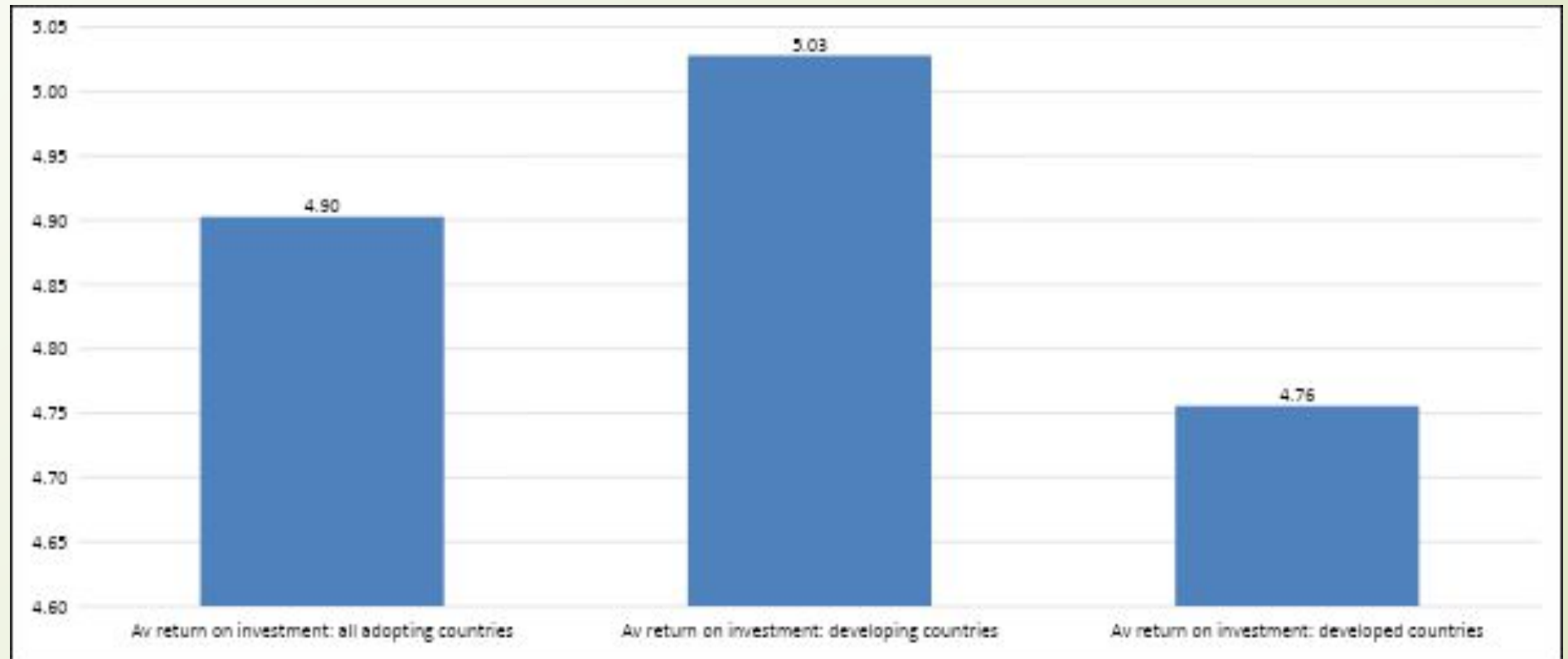
Theme: contribution to reducing agriculture's environmental footprint

- Since 1996, use of pesticides down by 867 million kg(-6.5%). Associated environmental impact (EIQ indicator)-15.3%
- Largest environmental gains from IR cotton: savings of 427 million kg insecticide use (-34%) and 29% reduction in associated environmental impact (EIQ measure) of insecticides
- Of which environmental gains from IR cotton in India: savings of 217 million kg insecticide use (-48%) and 37% reduction in associated environmental impact (EIQ measure) of insecticides

Return on investment in biotech seed (cost of accessing the technology) 1996-2024

\$ return per extra 1\$ spent on seed

Theme: Contribution to economic sustainability

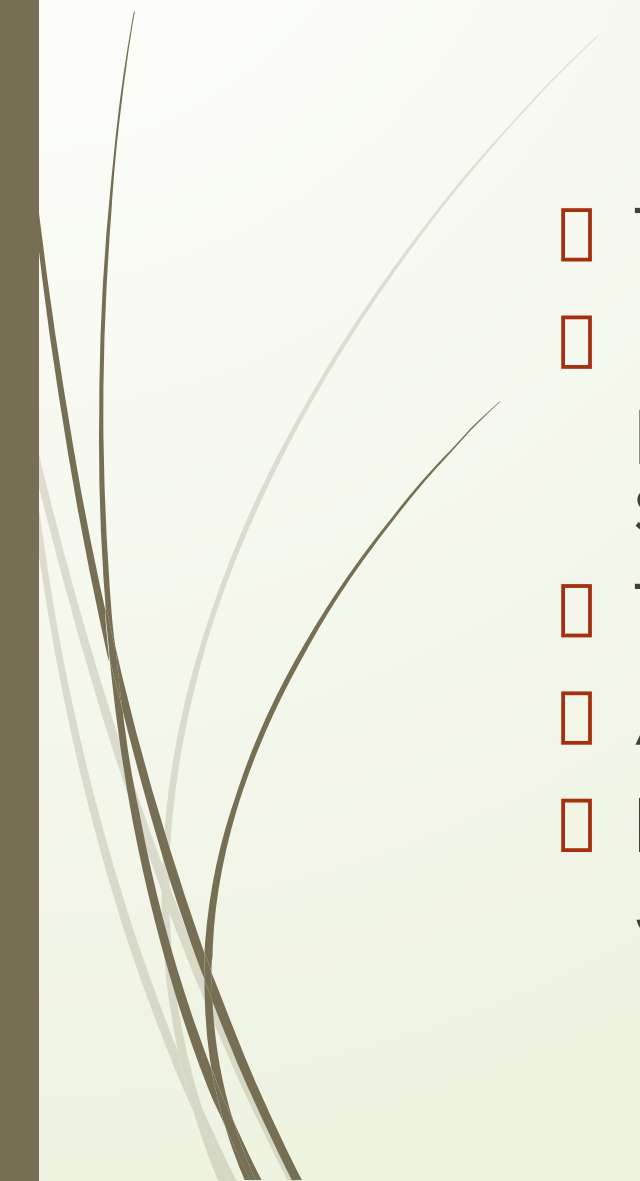


Cost of technology goes to seed supply chain (sellers of seed to farmers, seed multipliers, plant breeders, distributors & tech providers)



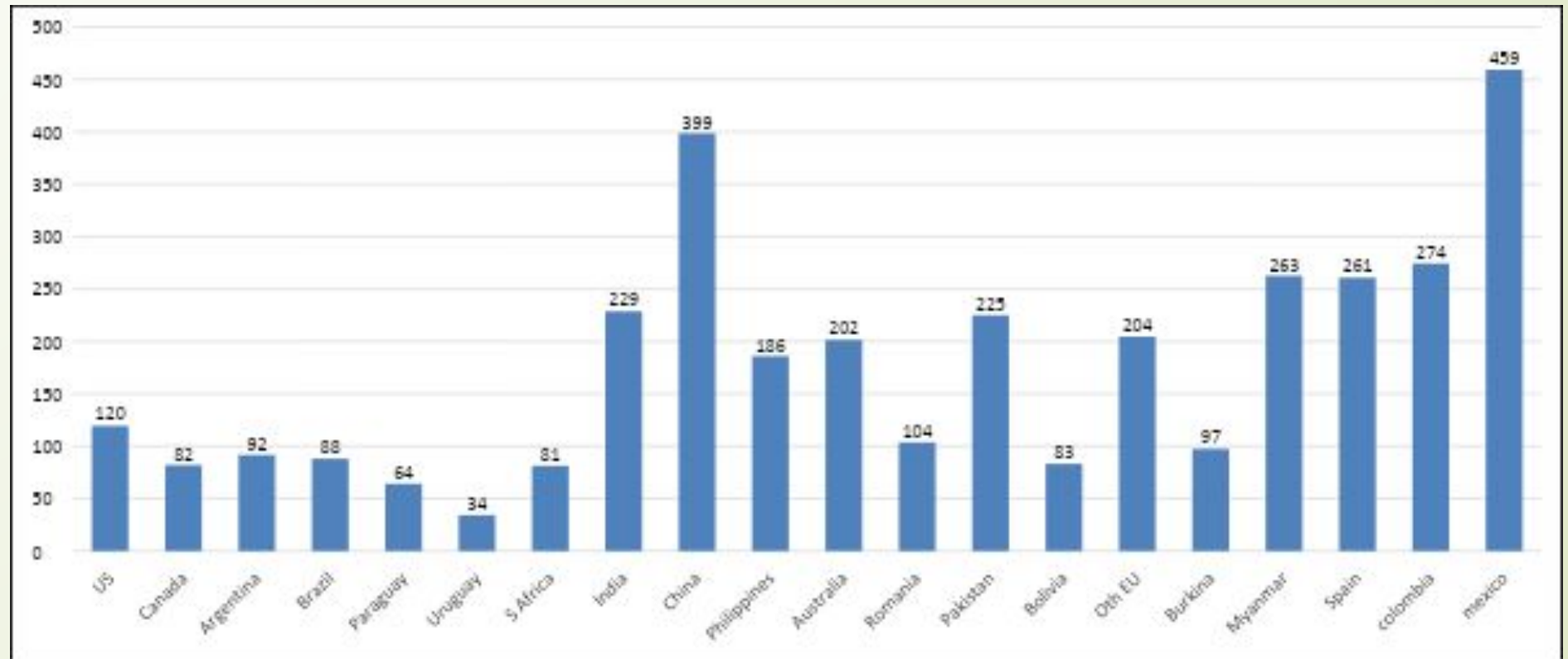
Farm income gains: highlights

Theme: Contribution to economic sustainability

- 
- Total farm income benefit 2024 \$29 billion
 - Equal to adding 6.4% to value of global production of corn, canola, cotton and soybeans
 - Total farm income gain: 1996-2024: \$384.9 billion
 - Average gain/hectare (1996-2024): \$106
 - Income share (1996-2024): 48% developed and 52% developing countries

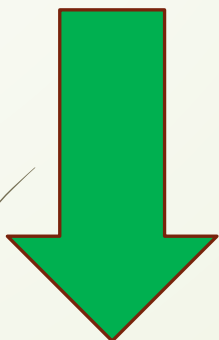
Average farm income gain 1996-2024 by country (\$/ha)

Theme: Contribution to economic sustainability



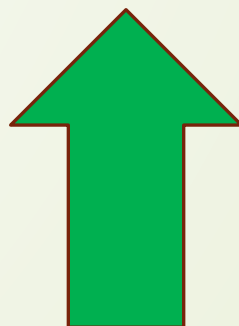
Summary of key findings

**Pesticide
change 1996-2024**



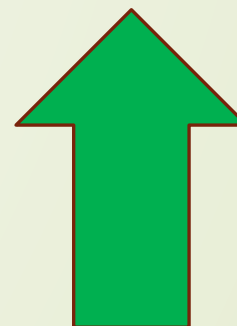
**867 million kg
reduction in
pesticides
(6.5%) & 15.3%
cut in
associated
environmental
impact**

**Global farm income
1996-2024**



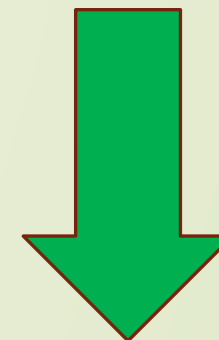
**\$385 billion
increase**

**Global production
1996-2024**



**1,345 million
tonnes more
food/feed/fibre**

**Carbon emissions
1996-2024**



**cut of 67 billion kg
CO2 release from
lower fuel use and
80-321 billion kg
from soil carbon
storage; equal to
taking 97-256
million cars off the
road**

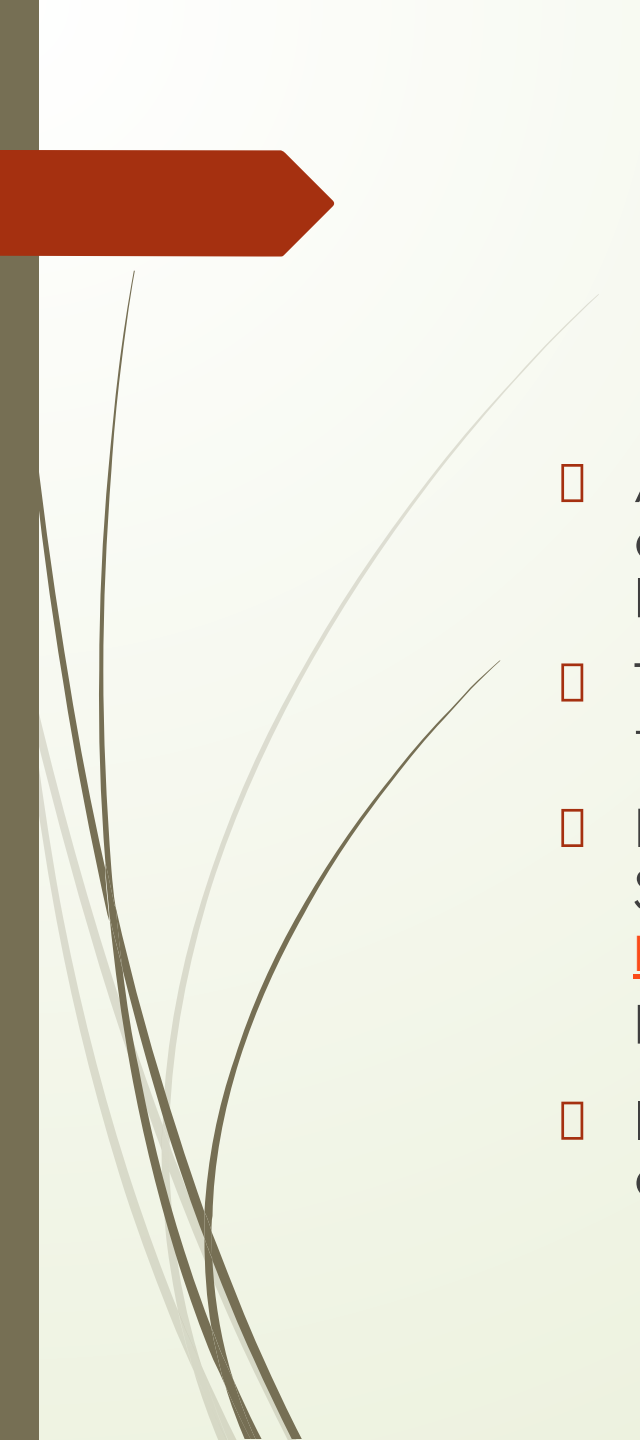


Any negatives?

- Over reliance on glyphosate by some farmers in North/South America (with HT crops) contributed to weed resistance problems – farmers had to adapt and change weed control systems resulting in increased herbicide use, higher cost compared to 20 years ago and some (limited) reversion to plough-based systems

BUT:

- *Weed resistance problems and increased herbicide use also a trend in conventional crops*
- *Environmental profile of herbicides used with HT crops remains better than equivalent on conventional crops*
- *HT crops remain more profitable than conventional alternative*
- *Limited development of pest resistance to early generations of IR traits – reduced effectiveness of technology and limited reversion to use of insecticides BUT:*
 - *Pest resistance problems – being addressed with newer traits with more modes of action and use of refuges*



Concluding comments

- After 25 years of widespread use – there is a considerable amount of **consistent** evidence in peer reviewed literature on the impact of biotech crop technology
- The technology has made a positive, net contribution to feeding the world in a more sustainable way
- Papers from this work submitted to GM Food and Crops journal. Socio-economic impact paper published at *GM Crops & Food*, 17(1). <https://doi.org/10.1080/21645698.2026.2726010>. Other 2 papers are ‘in the peer review process’ with the same journal
- I encourage you to read these papers and references cited in them and draw your own conclusions