Bayer: *Science for a better life*

Graham Head
Bayer U.S. –
Crop Science

Crop Science Mission

Shaping agriculture to benefit farmers, consumers and our planet

Bayer Crop Science

- Our world faces enormous challenges including a changing climate, limited natural resources and a growing population. And we believe agriculture is part of the solution.
- At Bayer, we're a responsible, global team working to shape agriculture through breakthrough innovation for the benefit of farmers, consumers and our planet.
- **More than a century** of agricultural expertise
- **~8,000** R&D employees, more than **35** R&D sites and **175** breeding sites worldwide*
- **€2.4 billion** annual investment to bring novel solutions to market*
- **Unmatched product portfolio** – from seeds and traits to biological and chemical crop protection
- **Cutting-edge digital tools** and information, enabling farmer decision-making
- Customers **spanning the globe**, representing farms of all types and sizes
- Established network of **240** partners devoted to innovation in agriculture

**Numbers based on company information and internal calculations | Bayer + Monsanto pro forma figures considering divestments | Monsanto calendarized to twelve-month period ended November 30, 2017*

Agriculture worldwide is facing new threats due to invasive agricultural pests

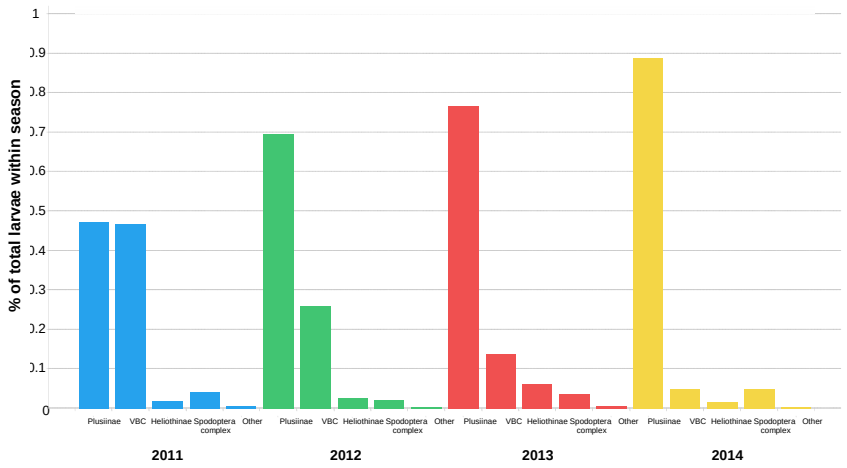
- **Pest invasions favored by:**
  - **Globalized agricultural markets,** with the same or similar crops and vegetables on every continent
  - **Global warming,** with most serious pests native in tropical or warm regions
  - **Cultural factors,** including limited pest management tools, level of education and poverty
- **Potential consequences**
  - Reduced yields
  - Reduced quality
    - Post harvest selection of ruined charges
  - Increased control costs (e.g. monitoring, insecticides, …)
  - Disruption of pest and resistance management strategies

Characterizing invasive pests: *Helicoverpa armigera*

- Native in the Palearctic, invasive in the Americas (Brazil 2013)
- Highly polyphagous, e.g. cotton, soybean, vegetables, corn
- Feeds on leaves, flowers, buds and fruits
- Most reported cases of insecticide resistance
- Fast lifecycle, high migration potential
- Annual crop losses in the billions
- Big threat to farmers, irrespective of farm size

Anderson et al. (2018) PNAS
Lopes et al. (2017) GMR
Kriticos et al. (2015) PLOS one
Pinto et al. (2017) insects
Tay et al. (2017) Sci. Rep.

Understanding the changing importance of different pest species over time

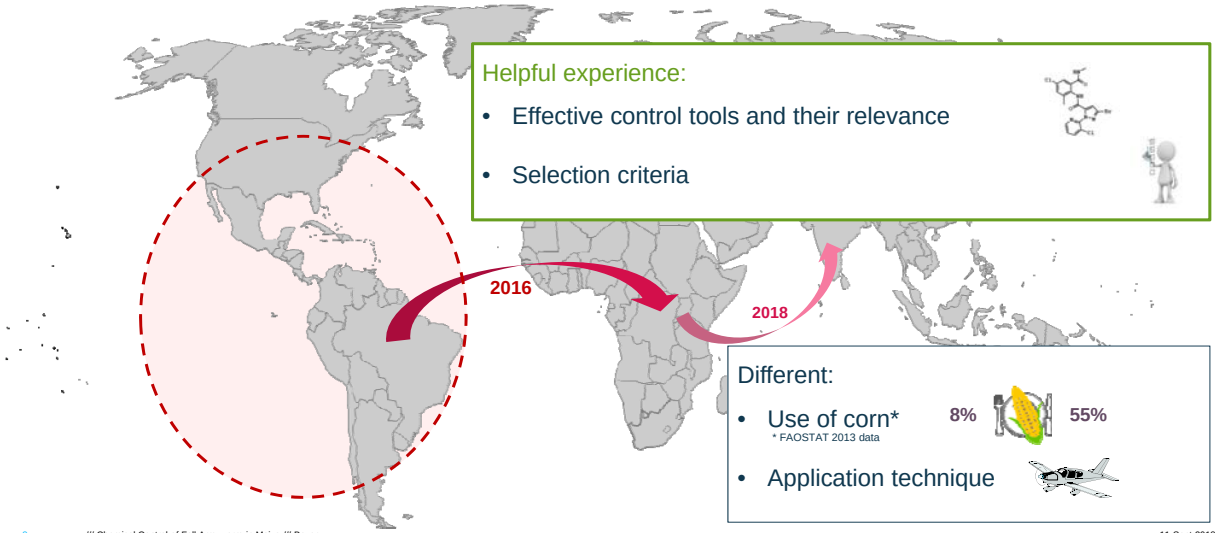


Source: *Legacy Monsanto Brazil (results not published).*

Identifying management tools: *Spodoptera frugiperda*

- Native to North and South America
- Invaded Africa 2016 (or earlier!) and spread east and south
- Over 100 host plants e.g. corn, rice, cotton, soybean, …
- Smallholder farmers in Africa have no experience with this pest
- Over 75% yield loss in Africa due to *S. frugiperda* is quite common without IPM, with the potential of 3 billion dollar loss Africa especially in smallholder farms
- Why is *S. frugiperda* a more severe pest than African *Spodoptera* species? (Goergen 2016)
  - Prefer corn vs. grasses in oviposition
  - Stronger mandibles (silica content of the leaves)
  - Larvae can be predatory on lepidopteran larvae

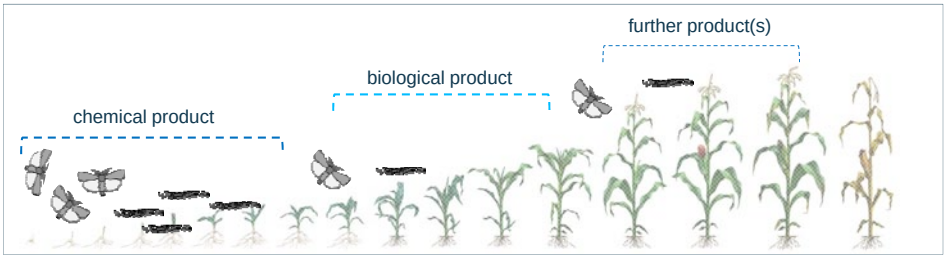
Use experience with *Spodoptera frugiperda* in corn in Americas



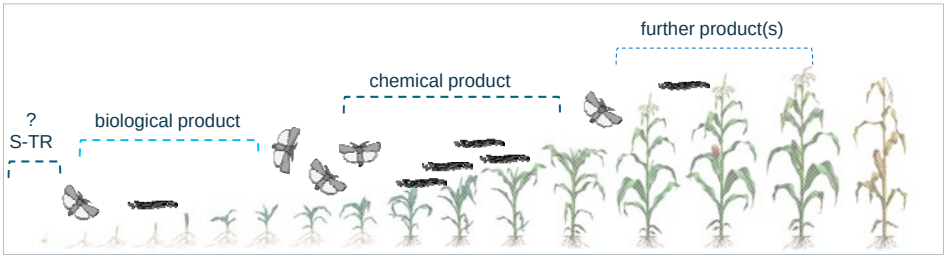
Options for integrated management programs

IPM: crop rotation – variety – crop systems – beneficial protection – **chemical & biological products** – a.o.

High infestation pressure **early**



High infestation pressure **later**



Selection of control tools in corn

Efficacy vs. Costs and Risk

Chemical Class	Efficacy *S. frugiperda*	Costs	additional Stewardship requirements	
			user	environment
Carbamates	**+++**	low	high	very high
Organophosphates	**++**	moderate	high - moderate	high
Pyrethroids	**++**	very low	moderate	high
Benzoylureas	**++**	low	low	moderate
Biologicals (B.t. foliar)	**+**	low	low	low
Spinosyns	**+++**	high	low	moderate
Diamides	**+++**	high	low	moderate

Source: Sales panel data 2016 / MSDS a.o. publicly available information

Support of responsible use of chemical products

Effectiveness, Safety and Environmental protection

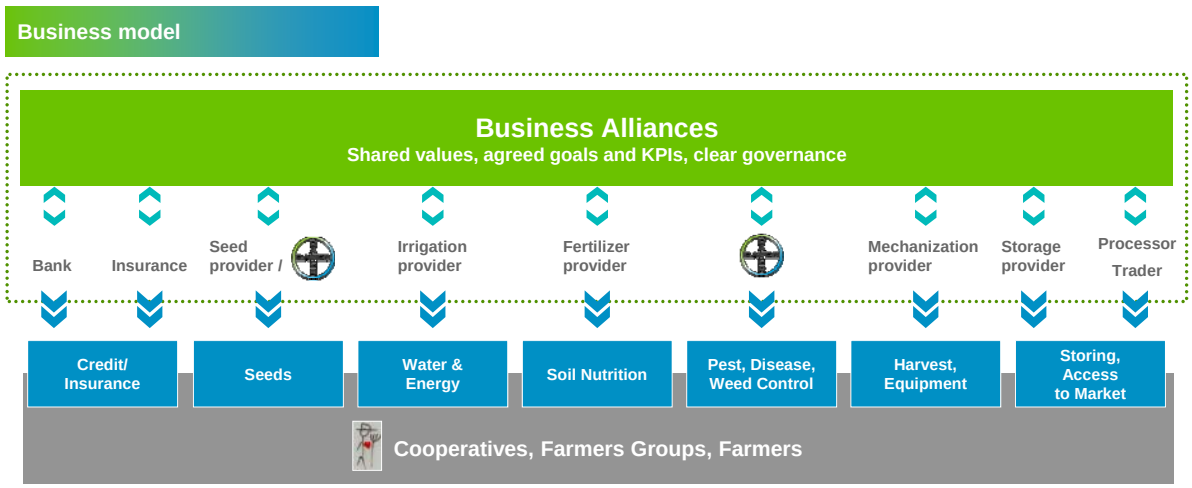
- Make products available (registrations and sales)
- Compliance with stringent registration requirements (intensive studies)
- Compound information, safety instructions and clear recommendations for use (technical info, package leaflet label)
- Education on pest knowledge (Identification, life cycle)
- Demonstrations for optimum product use (Scouting, trial demos, field days)
- Training on safe use of chemical products (handling, user protection equipment, application techniques, REI)
- Instructions on good agricultural practice (environment protection, residues, resistance management)
- Education on beneficials (identification, life cycle)
- Programs to establish refuge areas (beneficial protection, biodiversity)

Cooperation of industry, governments, non-governmental organizations, institutes, universities, advisers, farmer associations and lead farmers

Smallholder farming initiative for advanced/emerging farmers

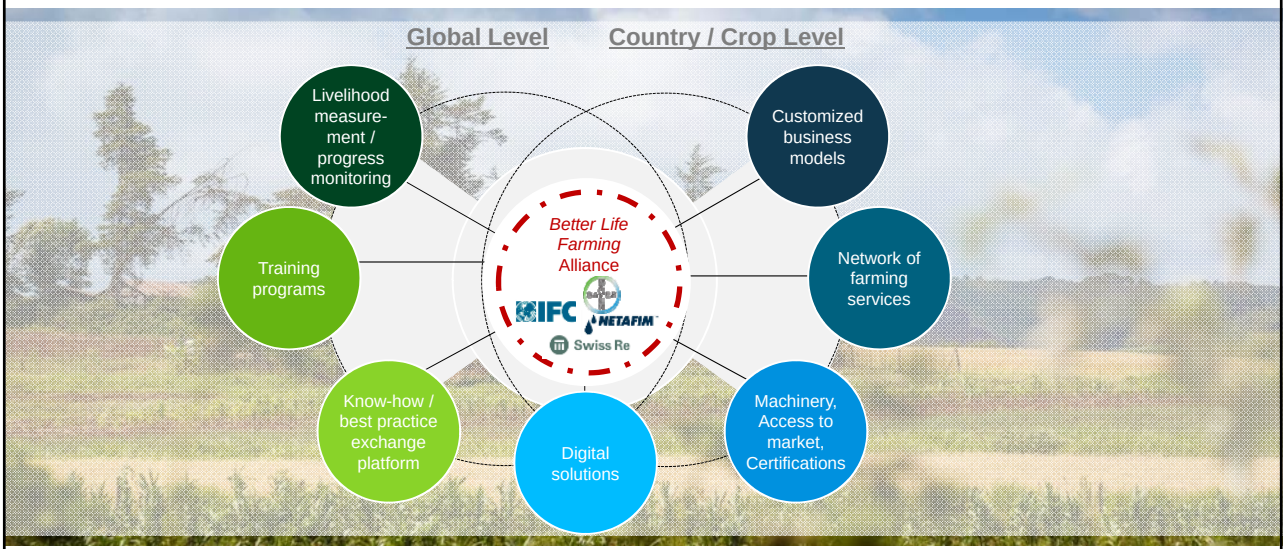
1. Adapted from C.K. Prahalad; 2. Estimated based on FAO data Smallholder Farming

Together with our partners we aim to offer solutions for the entire value chain

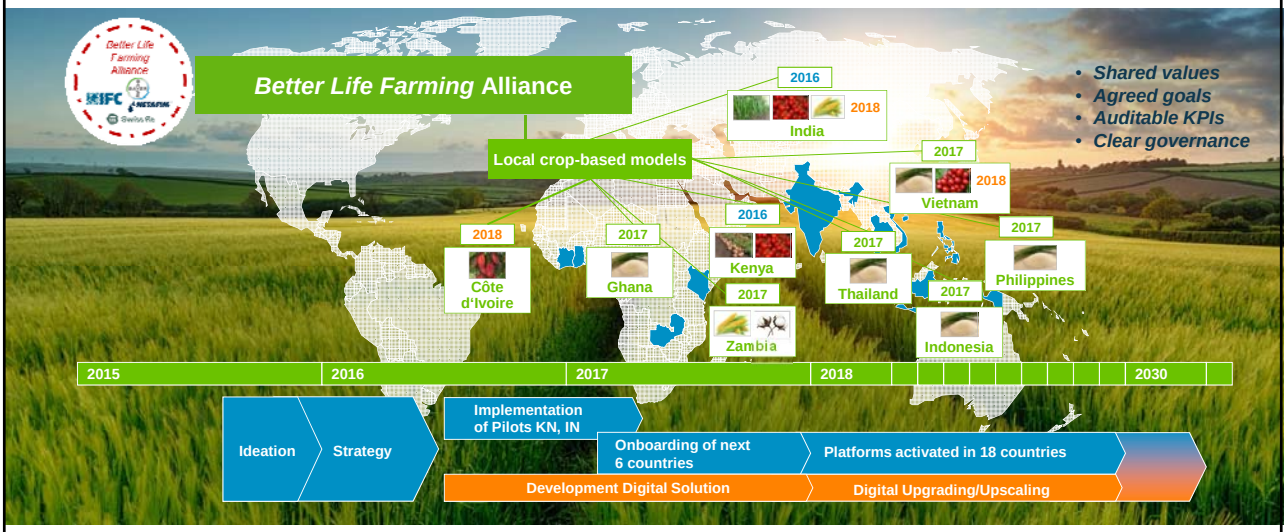


"Better Life Farming" Alliance

Global partnership to drive local success



Pilots in different countries to validate the approach



Thank you

for telling our story