Introduction to Agriculture

Capital Markets Day
London, December 5, 2018

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Agenda

// **1** The Case for Investment

// **2** Global Ag Market Snapshot

// **3** Planting Decisions

// **4** Creating Solutions for Farmers

// **5** Appendix

Need for Innovation Driven by Megatrends

Producing More with Less: A Fundamental Driver for our Crop Science Business

Megatrends through 2050

Growing Population

+2.2bn
people[1]

+50%
more food and feed required to meet growing demand and changing diets[2]

Pressure on Ecosystems

-17%
Harvest losses from climate change[3]

-20%

2016 2050
Significant loss in arable land per capita[4]

Societal Needs

Secure a sufficient supply of quality food

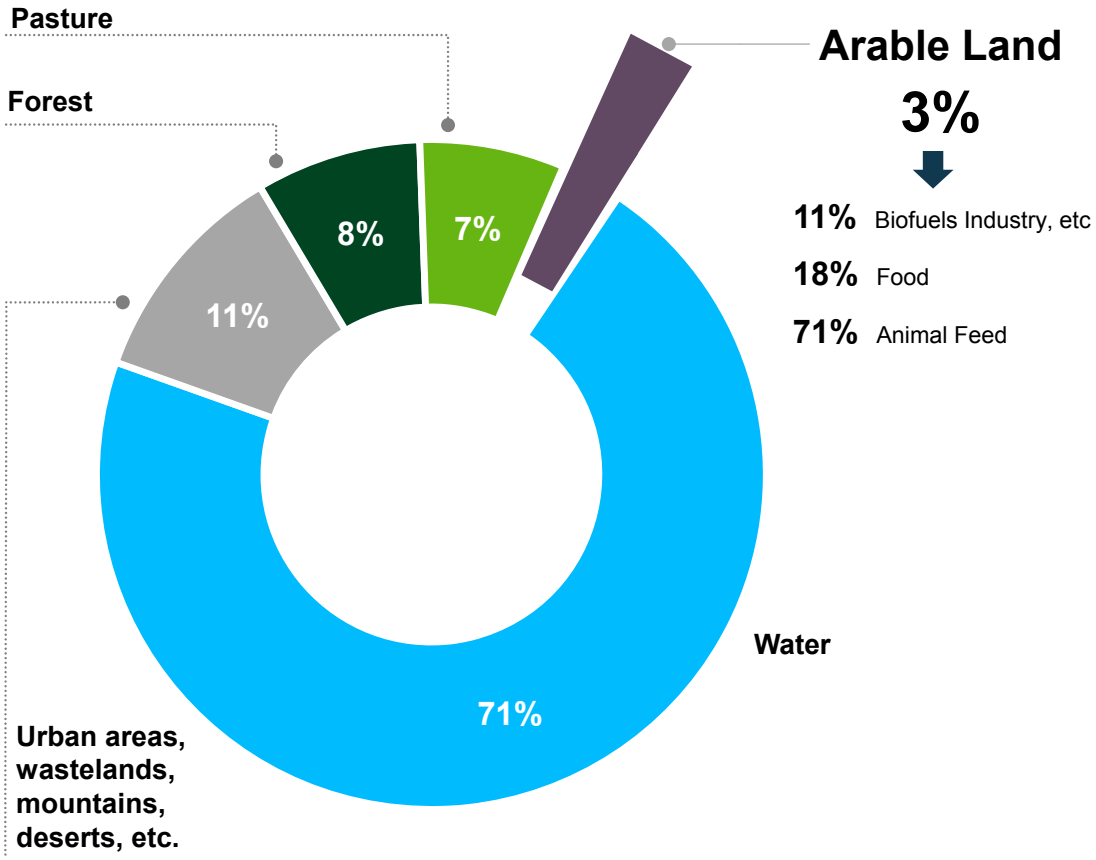
Use natural resources more efficiently and responsibly

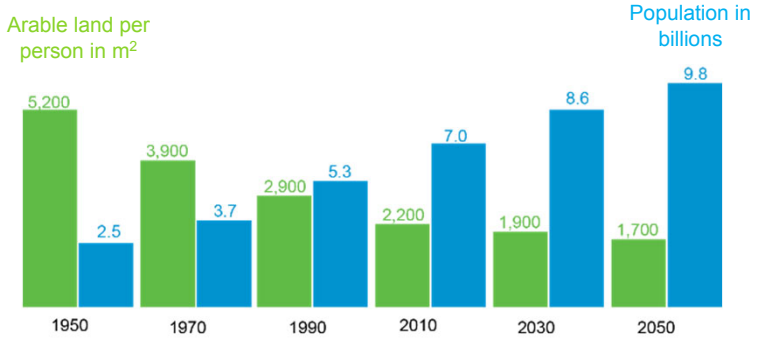
Science For A Better Life

[1] UNDESA 2017 (United Nations Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision); [2] FAO 2017 (FAO Global Perspective Studies)
[3] Nelson et. all. (2104); (2) FAO 2016 "Climate change and food security"; [4] FAOSTAT (accessed Oct 30, 2018) for 1961-2016 data on land, FAO 2012 for 2030 and 2050 data on land, and UNDEDA 2017: World Population Prospects for world population data.

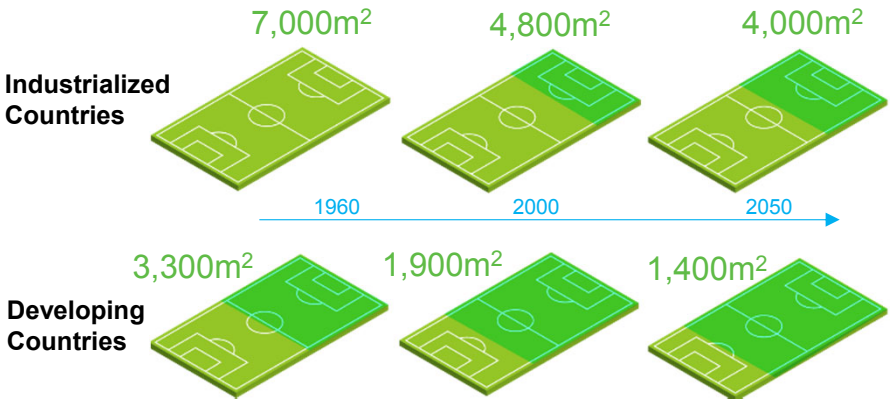
Land is Precious

Only 3% of Earth's Surface is Arable Land that's Able to be Farmed





In developing countries, the amount of arable land per person will be falling by more than 60 percent (1960-2050)



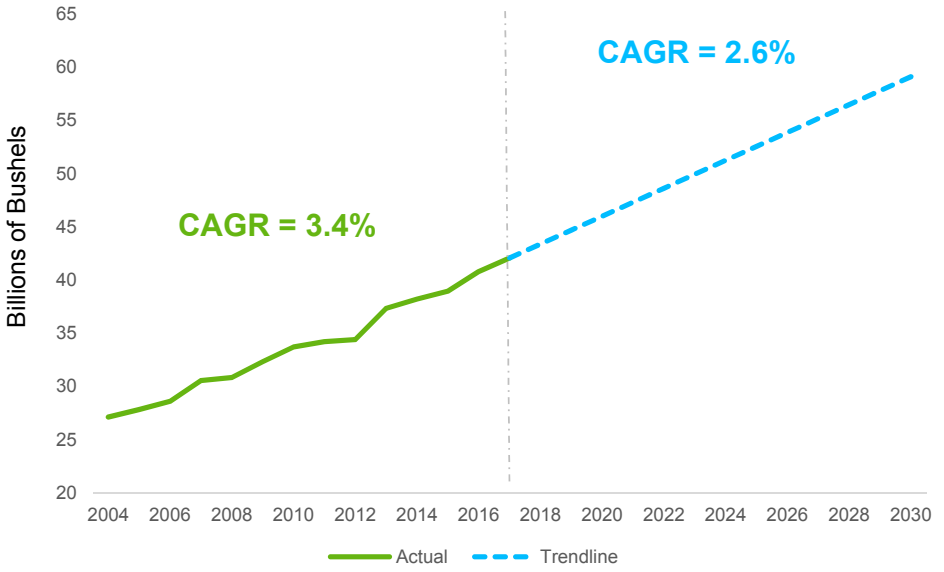
Amount of usable land per person in m^2 in comparison to a 7,140m^2 football field (rounded figures)

Trendline Demand Requires Substantive Yield Improvement

Global Corn Yield Rate of Gain must More than Double and Soybean Yield Rate of Gain must Triple by 2030

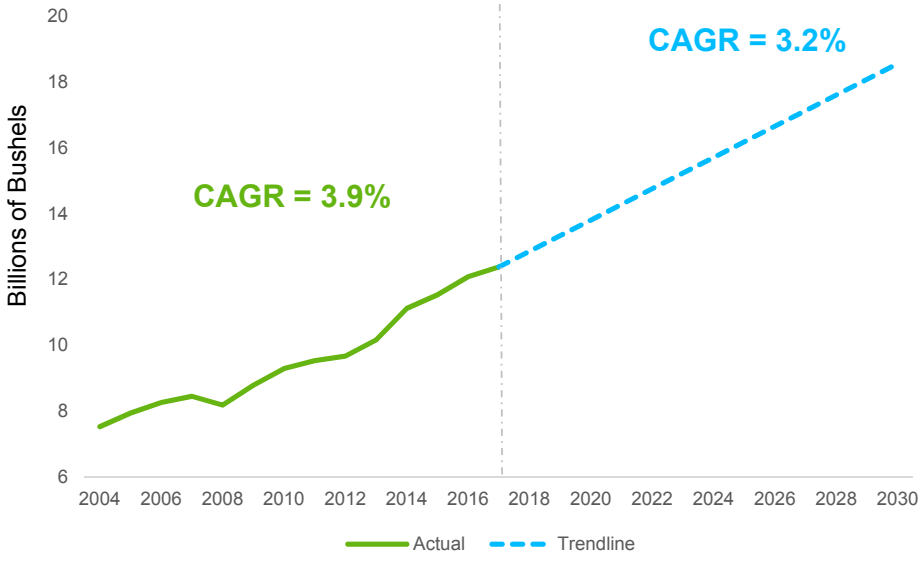
Long-term Demand Trendlines[1]

Corn



Incremental corn demand of ~1bn bushels expected in 2018/19 would require 13m additional acres of arable land at constant global yields

Soybean



Incremental soybean demand of ~600m bushels expected in 2018/19 would require ~14m additional acres of arable land at constant global yields

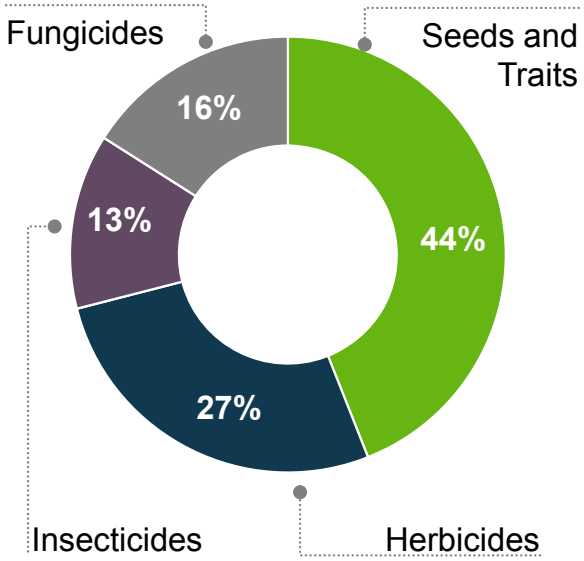
[1] USDA WASDE September 2018, historical data for actual and trendline, trendline based on avg. growth from 2011-2017

Agriculture Sales by Crop And Input

Corn and Soybean Lead in Value of Inputs; Cereals in Acreage

Total Ag Input Market: By Input

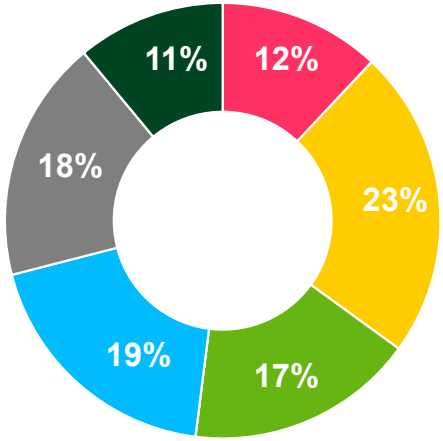
Total Market Value €90bn[1]



~3% Annual Growth

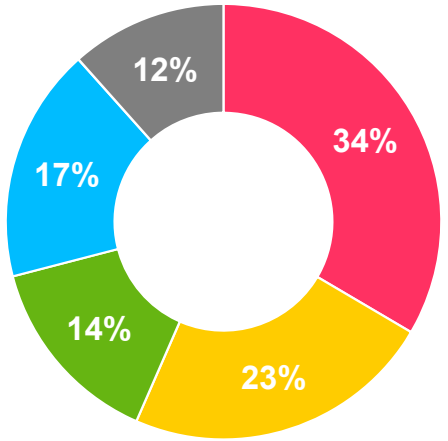
Total Ag Input Market: By Crop

Total Market Value €90bn[1]



Planted Area: By Crop, in %

~ 2bn ha (2017)



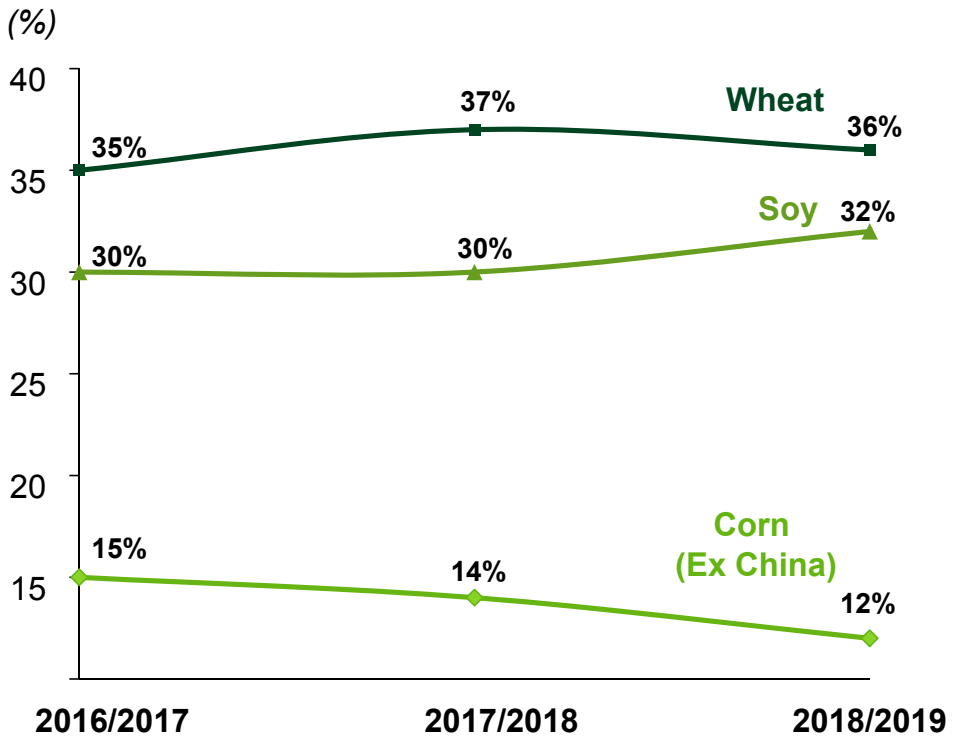
Cereals | Corn | Soybean | Horticulture | Others | Rice

Our focus crops of corn, soybean, cereals and horticulture account for ~70% of the market value and acres planted

[1] Total market of €90bn includes €5bn of Environmental Sciences; actual pie charts exclude that amount, as not relevant in these views
Source: Bayer CS market model

Global Stock-to-Use Ratios for Wheat and Corn Expected to Decline

Ratios Indicate Improving Market Dynamics in the Short-to-Medium Term



	2018/2019 Forecast			
	Harvested acres	Avg yield	Avg farm price	Prod Value
Wheat	535m	World 50 bu/ac EU 80 bu/ac	5.10 $/bu	$151.2bn
Soybean	321m	World 42 bu/ac U.S.A. 53 bu/ac	8.60 $/bu	$129.1bn
Corn	454m	World 93 bu/ac U.S.A. 181 bu/ac	3.50 $/bu	$188.5bn

Source: USDA-PSD/WASDE, November 2018. Average farm price is for the. U.S.A Production value from IHS Markit

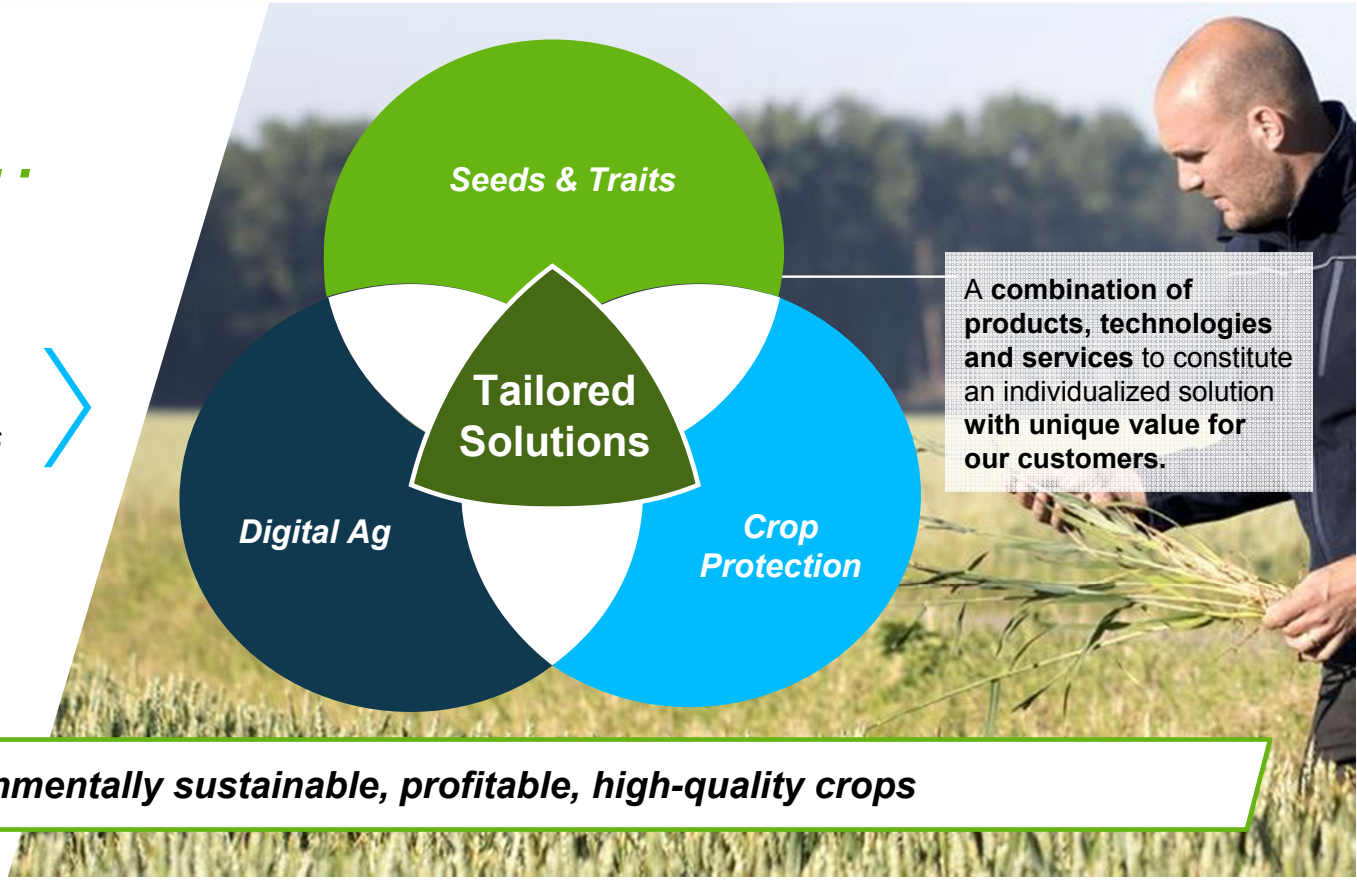
Tailored Solutions to Address Farmers' Individual Needs and Challenges

We know growers…

// …make approximately ***40 key decisions*** every season

// …want to grow the ***best seed varieties***, and minimize ***pests, diseases & weeds***

// …want to balance ***societal, economic & environmental needs***



Continuous innovation to drive environmentally sustainable, profitable, high-quality crops

Growers Face ~40 Key Decisions Each Growing Season

Digital tools and a Broad Portfolio of Solutions Allow Growers to Optimize Those Decisions

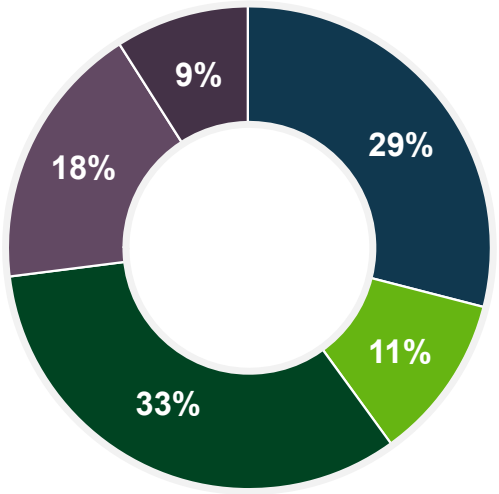
Planning	Pre-Planting	Planting	In-Season	Harvest
Production Planning	Production Planning	Seed Depth	Keep Stand or Re-Plant	Equipment
Crop Rotation	Fertility Program	Planting Speed Through the Field	Post-Emergent Herbicide Application	Timing
Weed Control Program	pH Management	Other Planting Operation Decisions	Foliar Insect Control	Storage
Row Spacing	Burn-Down Program	Plant Population	Fertility Program	Post-Harvest Assessment
Product Selection	Tillage Level	Starter Fertilizer	Foliar Disease Control	Crop-Marketing Support
Refuge Options	Primary Tillage Program	Herbicide Application	Irrigation Application In-Season	
Plant Population		Soil Insecticides	Micronutrients/ Fertility Management	
Seed Treatment		Fungicide Application-in-Furrow		
Soil Insecticides		Product Selection In-Field		
Soil Nematicides				

Economics Highly Influence Farmer Decision Making…

2018 Indicative Variable Grower Production Cost Budget Examples

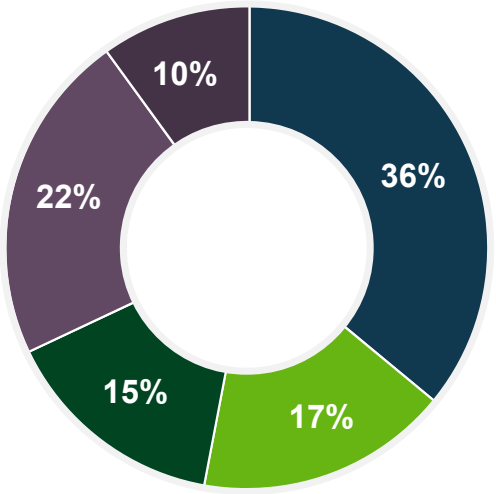
Corn – U.S.A.

Total ~ $840/ha or $340/acre



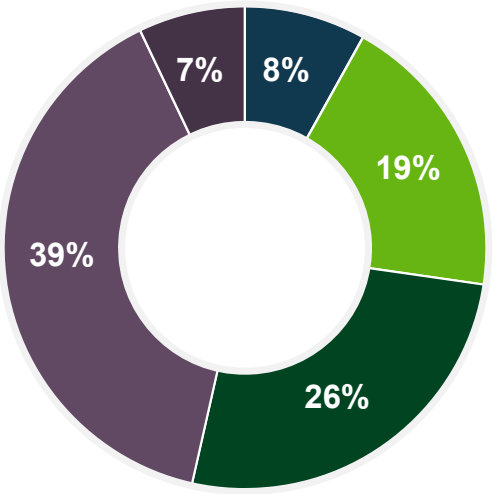
Soybean – U.S.A.

Total ~ $270/ha or $110/acre



Wheat – France

Total ~ 1050 $/ha or $425/acre



Seed | Crop Protection | Fertilizer | Other operating cost | Fuel, electricity

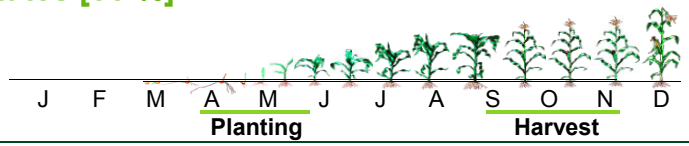
Source: USDA Forecast 2018

…as do Location and Timing

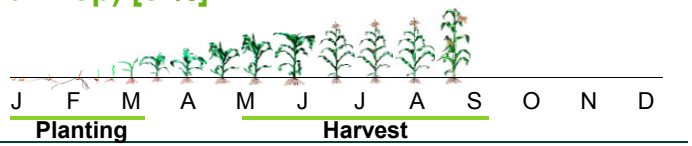
Decisions Take into Account Both Time of Year and Climate

Corn

United States [35 %] [3]

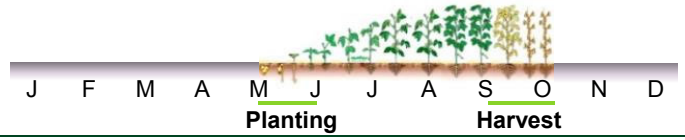


Brazil (Safrinha Crop) [8 %] [3]



Soybean

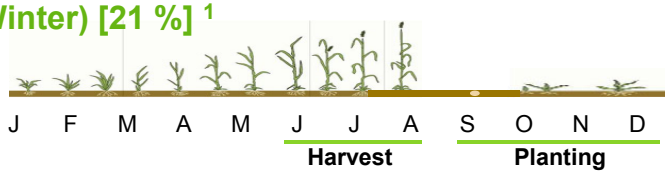
United States [33 %] [2]



Brazil [30 %] [2]

Wheat

Europe (Winter) [21 %] [1]



Australia (Winter) [3 %] [1]

Seeds are typically sold up to 6 months prior to planting start

Crop Protection buying season starts prior to planting, and continues throughout the plant growth phase until shortly before harvest

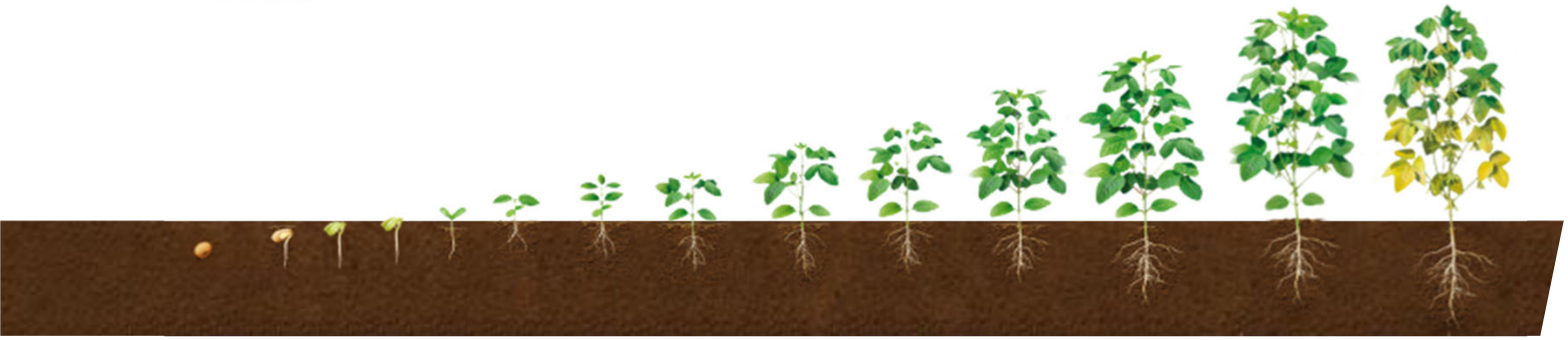
[1] Percentage refers to the global share of production (avg. 2013-2017) - EU/Australia figures refer to total (spring & winter) wheat production
[2] Percentage refers to the global share of production (avg. 2013-2017)
[3] Percentage refers to the global share of production (avg. 2013-2017); Brazil refers to total (1st & 2nd Crop) Corn production

Tailored Solutions Enable Optimal Grower Productivity

Optimizing Decisions for Growers to Produce More with Less

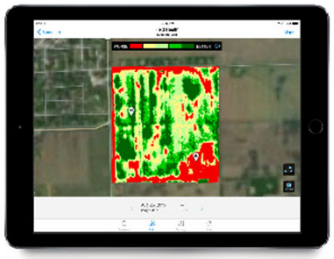
Superior products and use of digital tools like Climate FieldView across the Brazil soybean season

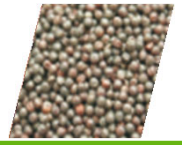
INTACTA RR2 PRO™ ASGROW CropStar Roundup CONNECT BELT FOX SPHERE® MAX



CLIMATE FIELD VIEW™

Digital Farming



Seeds & Traits	Seed Treatment	Weed Management	Pest Management	Disease Management
				

Tailor-made customer solutions holistically enhance yield and sustainability, ensuring safe, healthy, and affordable food

Key Takeaways

Shaping Agriculture to Benefit Farmers, Consumers and our Planet

1. **Climate and population trends, combined with finite resources, demand innovation in Ag**
2. **Our focus is in the leading crops within the growing €90bn global Ag input market**
3. **Farmers make over 40 key decisions a season; our goal is to help them optimize with the best solution on every acre**
4. **We maintain strong competitive advantages in creating the leading seed, biotech trait and crop protection chemistry solutions**

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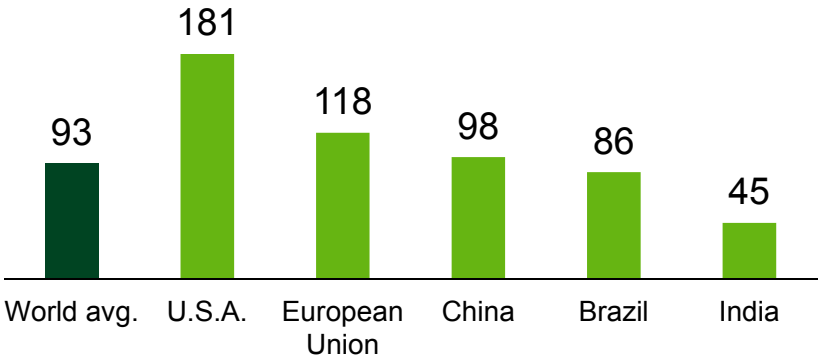
Appendix

Reference Materials

Highest Corn Yields in U.S.A.

Majority of Global Corn is used for Feed

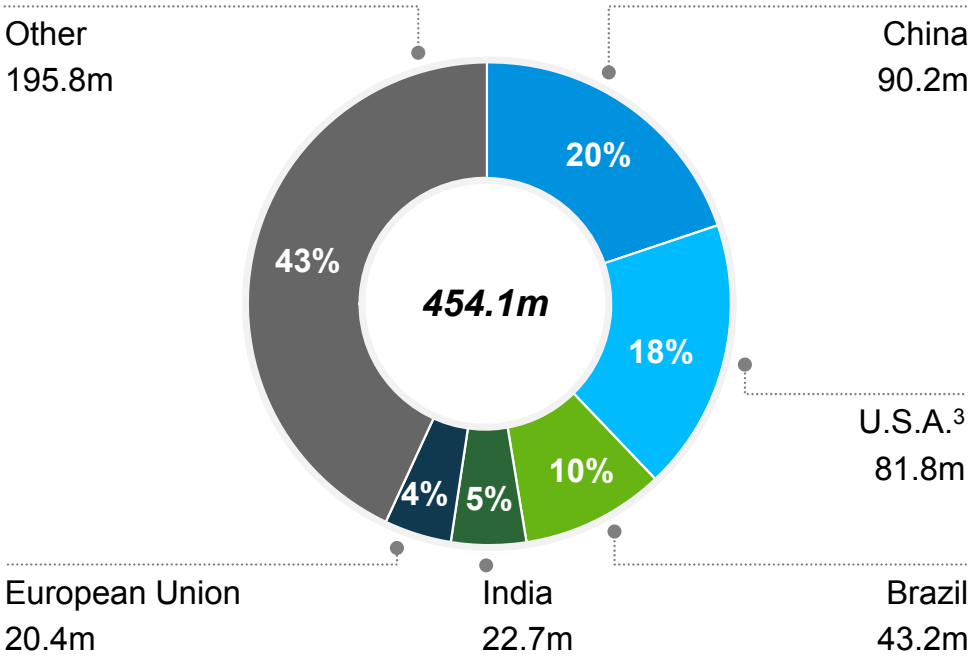
Corn Yields (bu/ac)[1]



Corn Use[2]

Feed	59%
Biofuel	18%
Food	13%
Other	10%

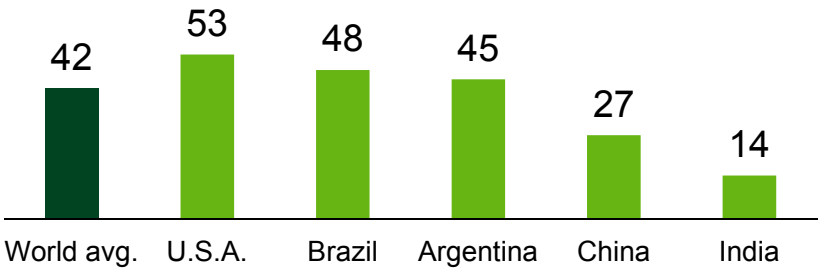
Major Corn Growing Countries (harvested acres)[1]



[1] USDA, Foreign Agricultural Service, Corn Area, Yield and Production as of 2018-10-11; 2018/19 Projections Oct
[2] OECD-FAO Agricultural Outlook 1990-2028; year 2017
[3] U.S.A. Corn planted acres: 89.1m (2018/19 Projections Oct)

Americas the Highest Yielding, Key Growing Region for Soybeans

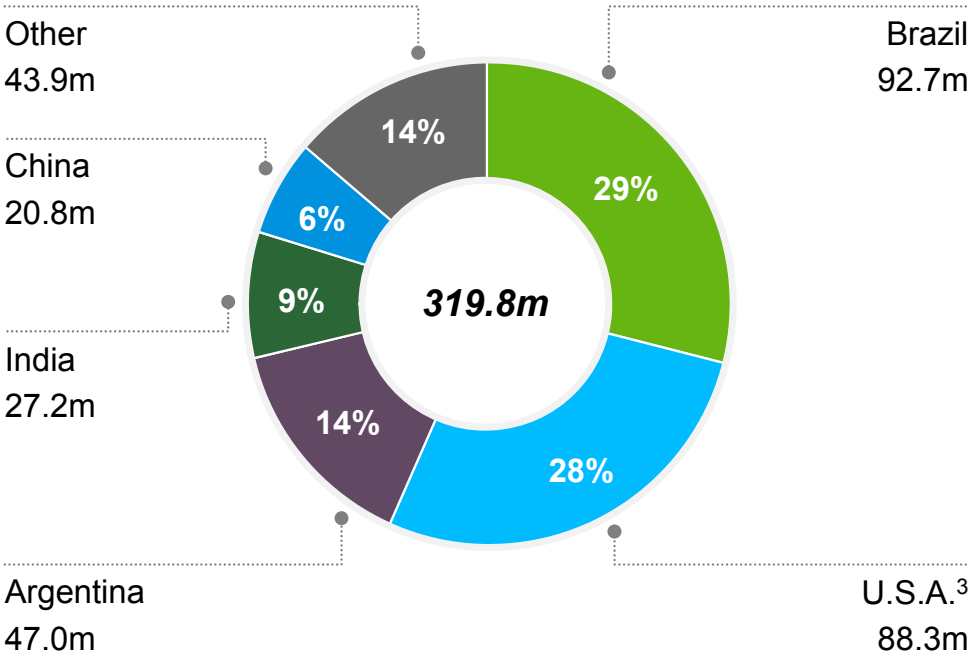
Soybean Yields (bu/ac)[1]



Soybean Use[2]

Crush (Meal and Oil)	89%
Food	5%
Feed	1%
Other	5%

Major Soybean Growing Countries (harvested acres)[1]



[1] USDA, Foreign Agricultural Service, Wheat Area, Yield and Production as of 2018-10-11; 2018/19 Projections Oct
[2] OECD-FAO Agricultural Outlook 1990-2028; year 2017
[3] U.S.A. Soybean planted acres: 89.1m (2018/19 Projections Oct)

A Quarter of Global Soybean Production Goes to China

China Tariff on U.S.A. Soybean Expected to Impact Global Trade Flows

United States	2018/19[P] mMT
Demand	60.1
Production	127.6
Exports	56.1

Argentina	2018/19[P] mMT
Demand	47.9
Production	57.0
Imports	2.2
Exports	8.0

Brazil	2018/19[P] mMT
Demand	46.2
Production	120.5
Exports	75.0

E.U.	2018/19[P] mMT
Demand	18.3
Production	2.7
Exports	15.8

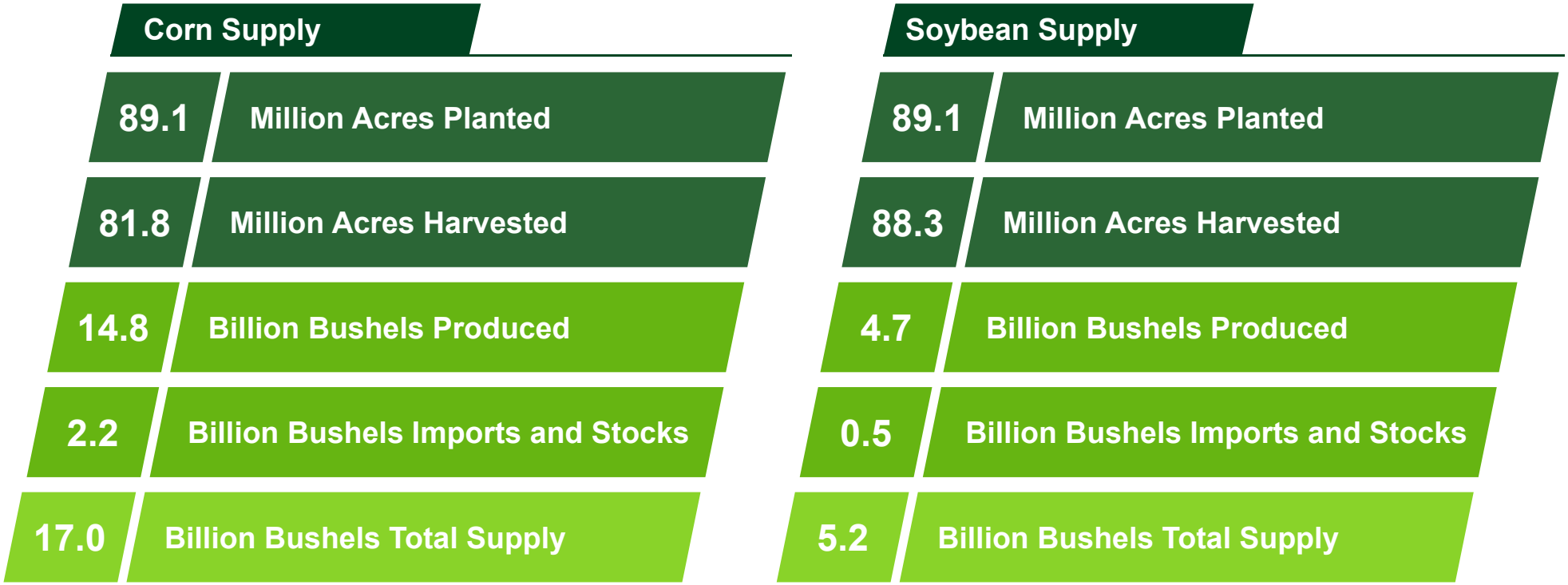
China	2018/19[P] mMT
Demand	110.6
Production	15.0
Imports[R]	94.0

// 28% from U.S.A
// 66% from BRA
// 2% from ARG

World	2018/19[P] mMT
Demand	353.0
Production	369.5

[P] USDA, World Agricultural Supply and Demand Estimates, October 11, 2018; 2018/19 Projections Oct
[R] Strategie Grains, October 25, 2018; Crop Year: 2017/18
mMT = million Metric Tons

The U.S.A. is a Major Supplier of Global Corn and Soybean

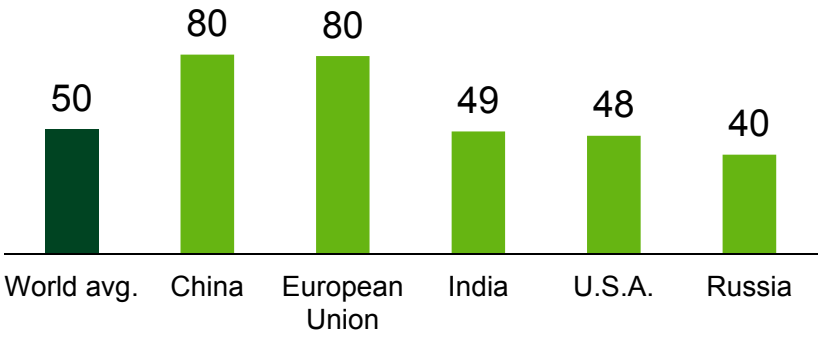


Source: USDA, World Agricultural Supply and Demand Estimates, October 11, 2018; 2018/19 Projections Oct

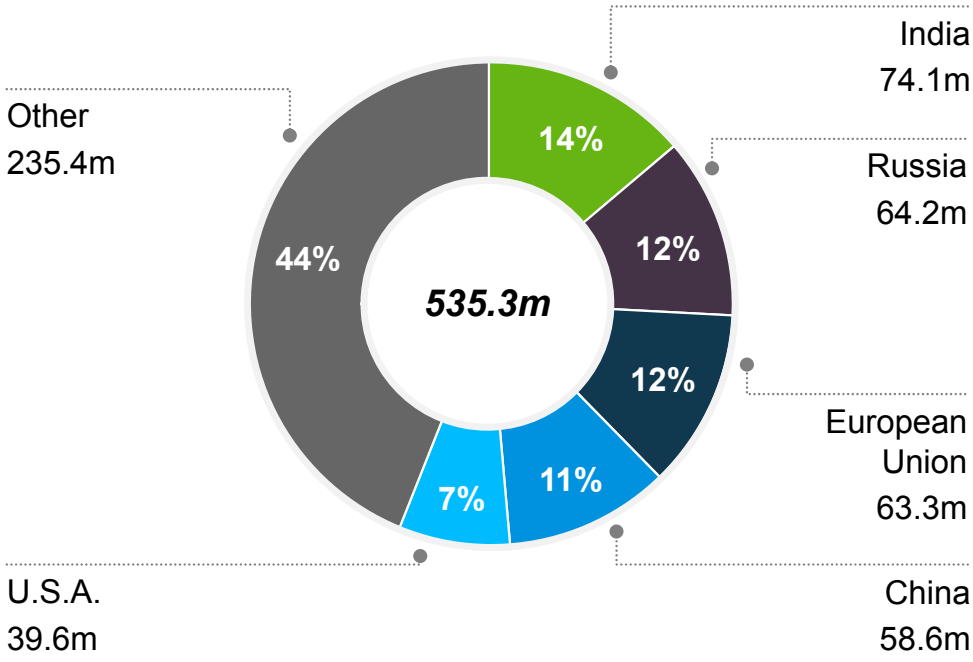
Wheat: Largest Global Staple Crop by Acreage

Only Conventional Varieties Grown

Wheat Yields (bu/ac)[1]



Major Wheat Growing Countries (harvested acres)[1]



Wheat Use[2]

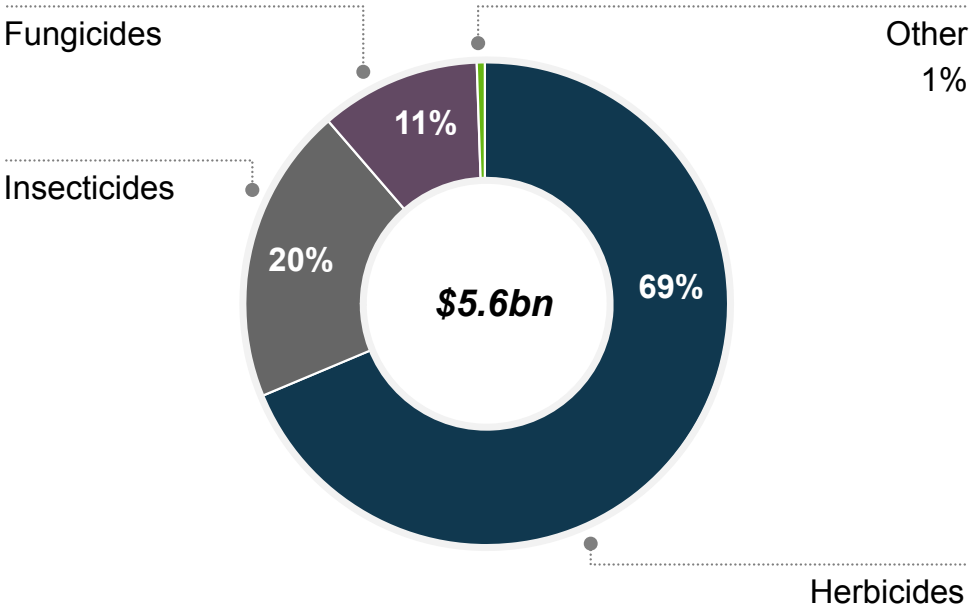
Food	68%
Feed	19%
Biofuel	2%
Other	11%

[1] USDA, Foreign Agricultural Service, Wheat Area, Yield and Production as of 2018-10-11; 2018/19 Projections Oct
[2] OECD-FAO Agricultural Outlook 1990-2028; year 2017

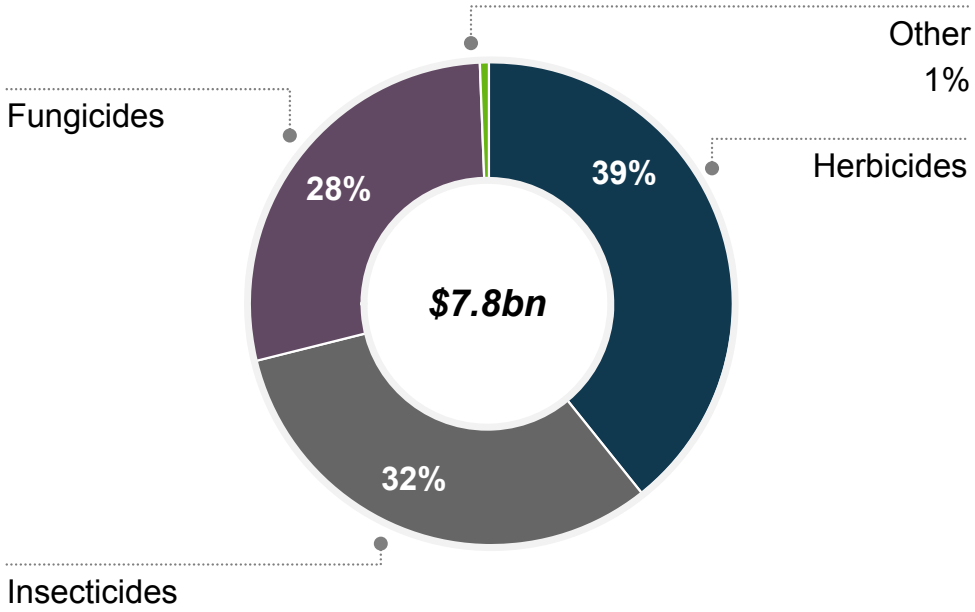
2016 Crop Protection Market by Crop and Segment

Corn / Soybean

Corn Crop Protection Market



Soybean Crop Protection Market

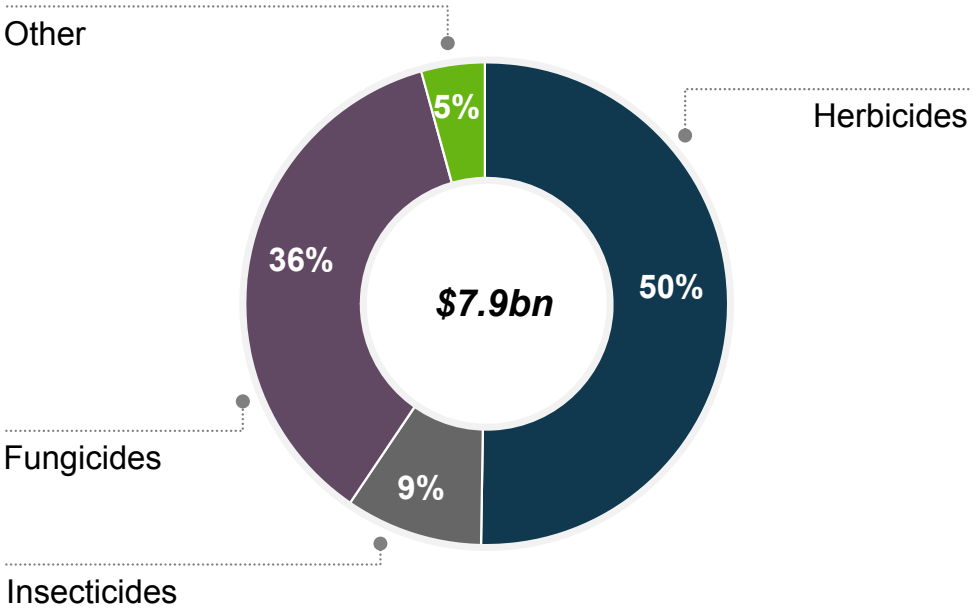


Source: Phillips McDougall AgriService 2017, Global Agrochecmial Market by Crop 2016

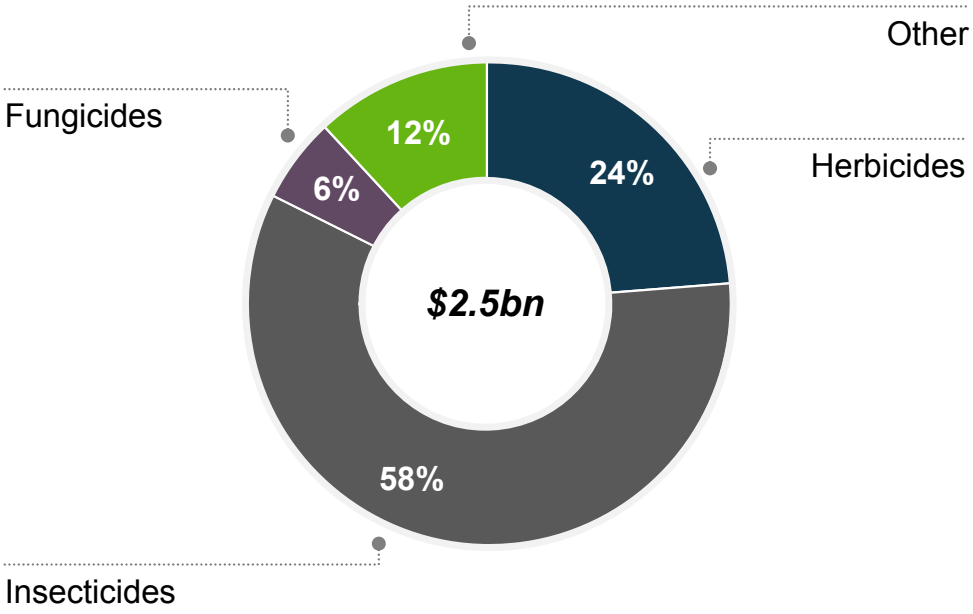
2016 Crop Protection Market by Crop and Segment

Cereals / Cotton

Cereals Crop Protection Market



Cotton Crop Protection Market

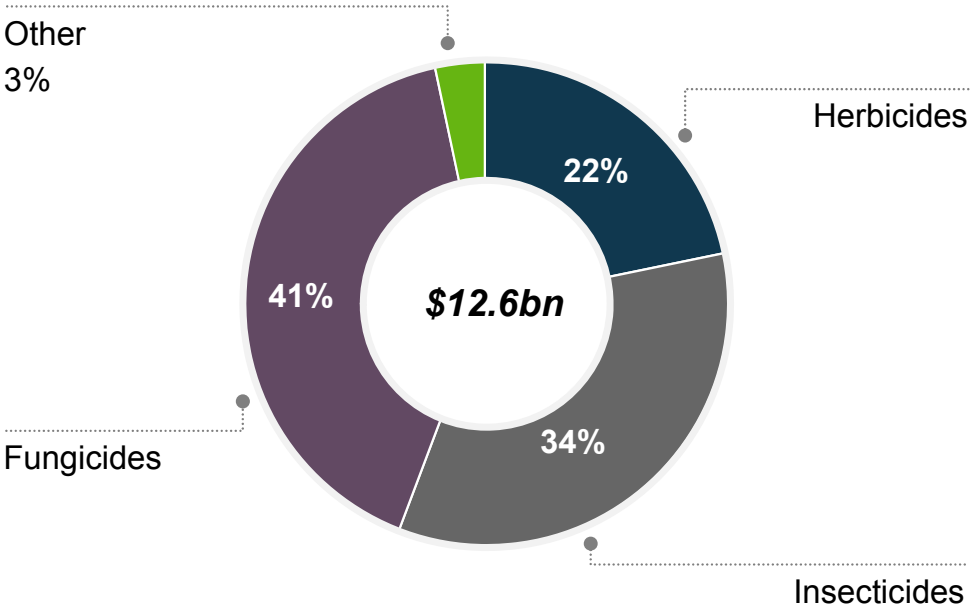


Source: Phillips McDougall AgriService 2017, Global Agrochecmial Market by Crop 2016

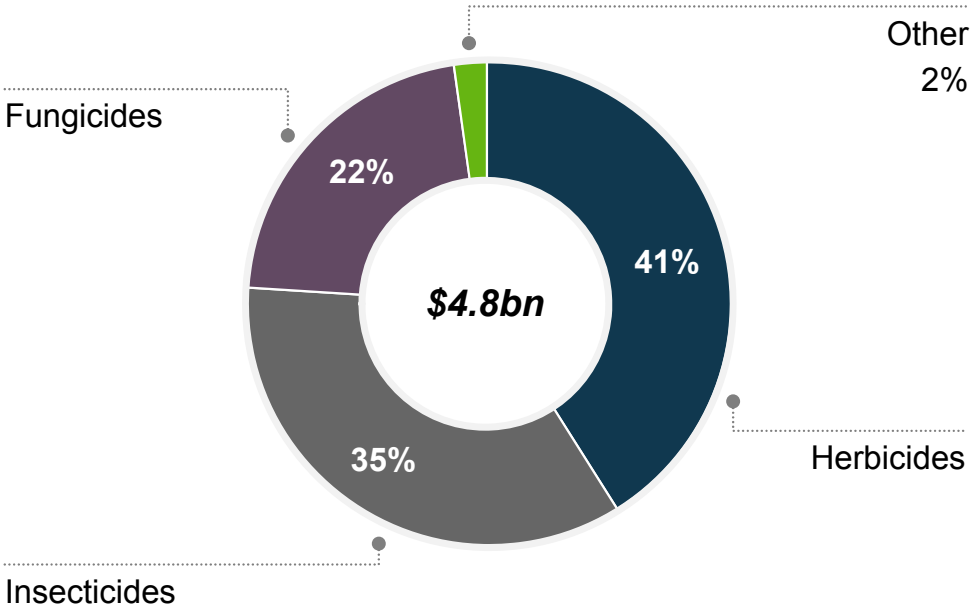
2016 Crop Protection Market by Crop and Segment

Fruit & Vegetables / Rice

Fruit & Vegetables Crop Protection Market



Rice Crop Protection Market



Source: Phillips McDougall AgriService 2017, Global Agrochecmial Market by Crop 2016

Leading Corn Seed and Trait Products and Brands

United States

BRANDED SEED PRODUCTS:
- *SmartStax RIB Complete*
- *VT Double PRO RIB Complete*
- *VT Triple PRO RIB Complete*
- *DroughtGard VT Double PRO RIB Complete*
- *Trecepta (offered with VT Double PRO)*
- *Roundup Ready Corn 2*

LICENSED CORN GERMPLASM
- *Corn States*

SEED BRANDS:
- *DEKALB*

Regional:
- *Fontanelle Hybrids - NE*
- *Gold Country Seed - MN*
- *Hubner Seed – East U.S.A.*
- *Jung Seed Genetics - WI*
- *Kruger Seeds - IA*
- *Lewis Hybrids - MO*
- *REA Hybrids – North U.S.A.*
- *Stewart – IN, KY and OH*
- *Stone Seed – IL*
- *Specialty – IN and MI*
- *Channel (direct)*

Brazil

BRANDED SEED:
- *VT Triple PRO*
- *VT Double PRO*
- *VT PRO*
- *Refuge MAX (Roundup Ready only)*

SEED BRANDS:
- *DEKALB*

Regional:
- *Agroeste*
- *Sementes Agroceres*

Argentina

BRANDED SEED
- *VT TRIPLE PRO*
- *YieldGard RR2*
- *Roundup Ready Corn 2*

SEED BRANDS:
- *DEKALB*

Regional:
- *La Tijereta*

E.U.

BRANDED SEED
- *Conventional*

SEED BRANDS:
- *DEKALB*

Leading Soybean and Cotton Seed and Trait Products and Brands

United States

Soybean

BRANDED SEED PRODUCTS:
Roundup Ready 2 Xtend
Roundup Ready 2 Yield

LICENSED SOYBEAN GERMPLASM
Corn States

LICENSED CORN GERMPLASM
Corn States

SEED BRANDS:
Asgrow

Regional:
Fontanelle Hybrids - NE
Gold Country Seed - MN
Hubner Seed – East U.S.A.
Jung Seed Genetics - WI
Kruger Seeds - IA
Lewis Hybrids - MO
REA Hybrids – North U.S.A.
Stewart – IN, KY and OH
Stone Seed – IL
Specialty – IN and MI
Channel (direct)

Brazil

BRANDED SEED PRODUCTS:
Intacta RR2 PRO

SEED BRANDS
Monsoy
Asgrow

LICENSED SOYBEAN GERMPLASM
Monsoy

BRANDED SEED PRODUCTS:
Intacta RR2 PRO

United States

Cotton

BRANDED SEED PRODUCTS:
Bollgard II XtendFlex Cotton
Roundup XtendFlex Cotton

SEED BRANDS
Deltapine

LICENSED COTTON GERMPLASM
Cotton States

Australia

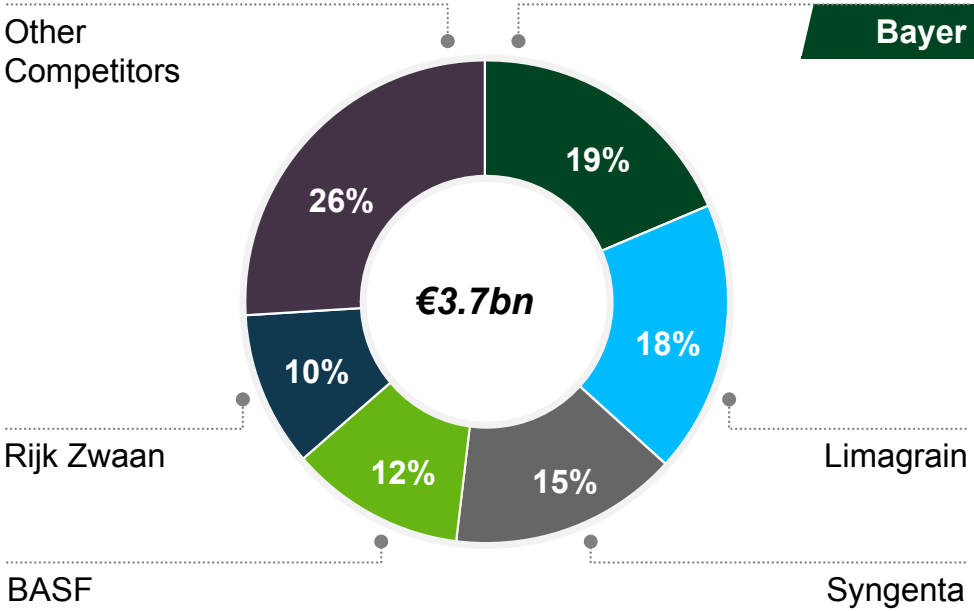
BRANDED SEED PRODUCTS:
Bollgard III Roundup Ready Flex Cotton
Roundup Ready Flex Cotton

India

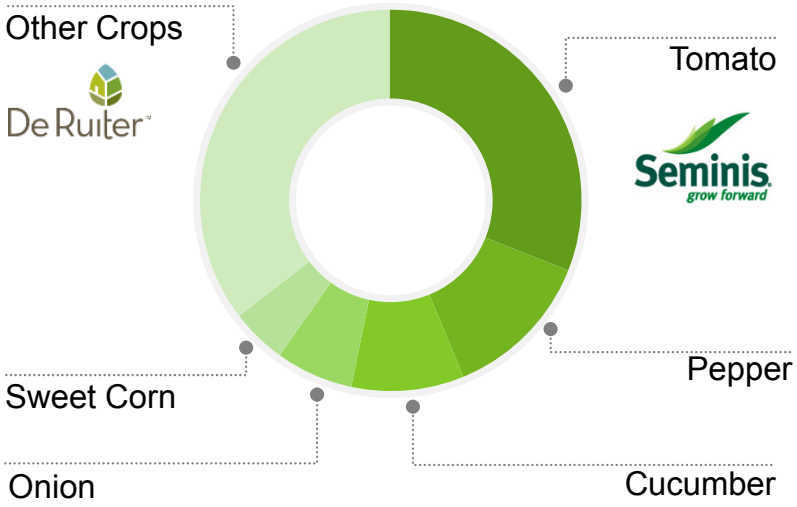
BRANDED SEED PRODUCTS:
Bollgard II Cotton

Bayer is a Global Leading Player in the Vegetable Seed Market

Major Players in Vegetable Seed (*sales*)[1]



Bayer Vegetable Seed sales by crop

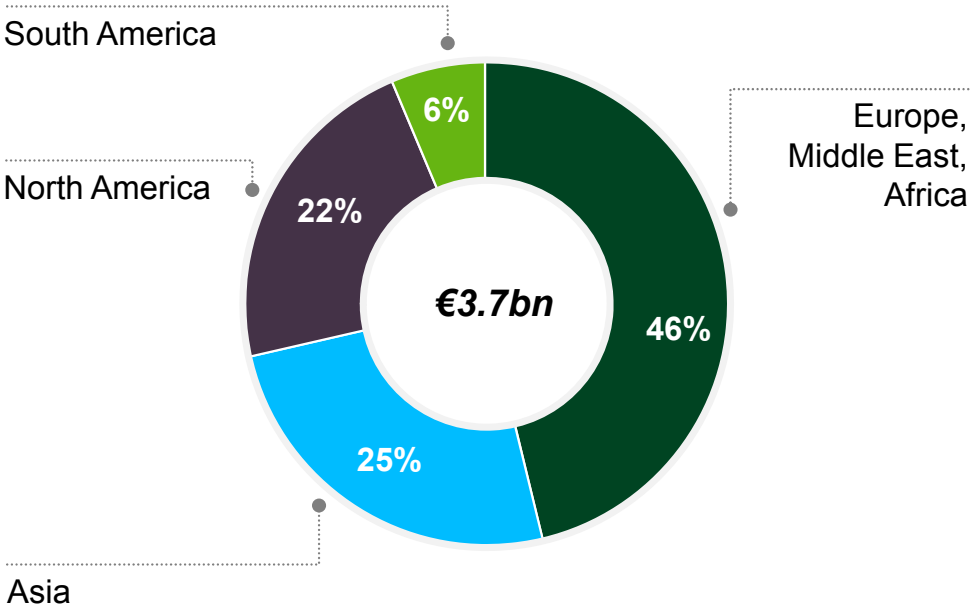


[1] Various external sources and internal estimates; 1 USD = 1.19 EUR

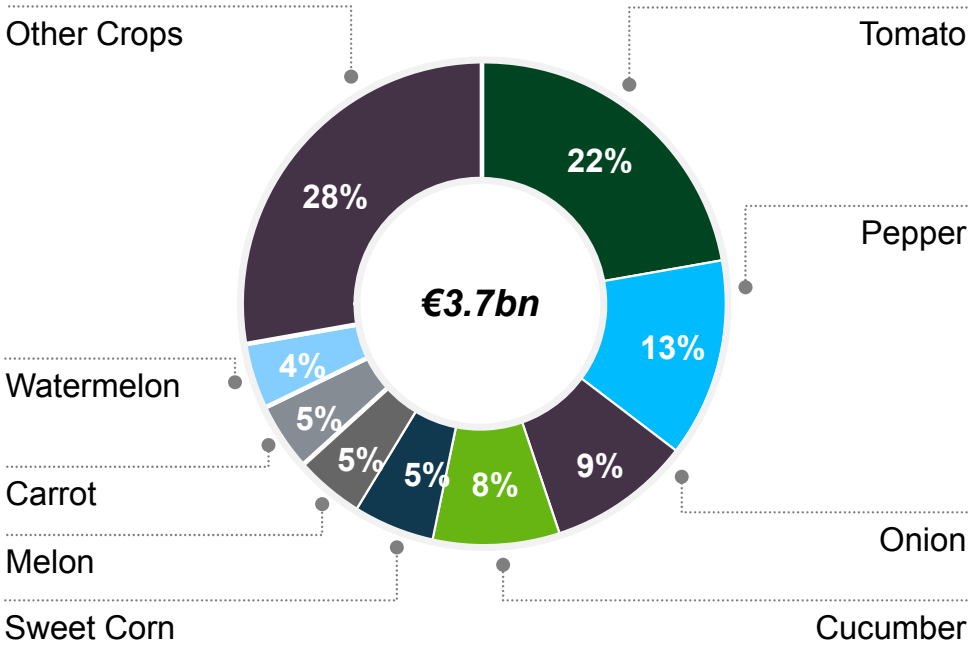
Our Focus Crops and Regions Align With Global Vegetable Market

Our Leading Crops are Tomatoes, Pepper, Cucumber and Regions are EMEA and North America

Vegetable Growing Regions (Value)[1]



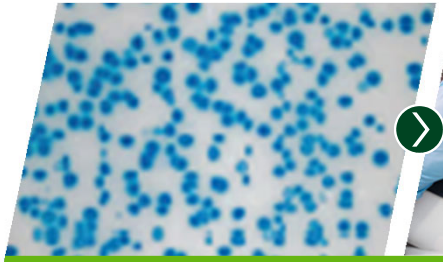
Major Vegetable Crops (Value)[1]



[1] Various external sources and internal estimates; 1 USD = 1.19 EUR

Developing World-Class Biotech Traits and Crops

Scale and Expertise in Biotech Crop Development Lead the Industry

Discovery	Phase One	Phase Two	Phase Three	Phase Four
				

Trait Development Process (11-12 years)

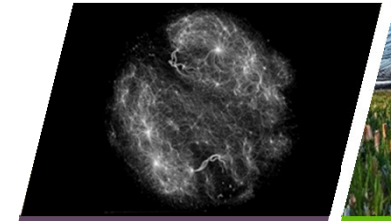
Gene / Trait Identification	Proof of Concept	Early Development	Advanced Development	Pre-Launch
// High-Throughput Screening for desired characteristic and Early Crop Testing	// Gene Optimization and Demonstration of Product Concept In-Crop	// Large-Scale Transformation, Commercial Candidate Selection, Pre- Regulatory Data Generation	// Trait Integration, Regulatory Data Generation	// Regulatory Submissions & Approvals, Seed Bulk-Up, System Testing and Pre-Marketing

Competitive Advantage

Gene / Trait Identification	Proof of Concept	Early Development	Advanced Development	Pre-Launch
✓ Industry-leading genome & germplasm libraries in house and through collaborations ✓ Best-in-class screening capabilities	✓ Technical expertise to optimize gene expression and performance in-crop ✓ Ability to rapidly test many gene combinations to evaluate stacks	✓ Knowledge of optimal genome locations ✓ Largest global field-testing footprint diversifies geographic data insights	✓ New traits are introgressed into the most elite germplasm, and stacked with the industry's leading traits	✓ Global regulatory experience is unrivaled ✓ Evaluation of agronomic systems (trait, germplasm, chemistry) for product deployment & customer recommendations

Scale and Leading Technology Drives Breeding Crop Development

Optimizing Extensive Germplasm Library to Develop New Capabilities for Better Customer Solutions



Germplasm "Galaxy"

// Stars represent inbred parents, connector lines represent ancestral relationships

// Representing breeding in 120+ locations in 25+ countries

Enabling Technologies

// 90% of NA corn 2018 commercial deployments are impacted by advanced methods

// Doubled haploids enable scale of breeding pipeline & faster cycle time

Testing in the lab
1 Beaker = 900,000 Plots
2 mo. Lab = 1 yr. in the Field

Sequencing & Selection In Lab

// Sequencing chip contains 1K genomes or 14 acres of information enables saving 1 year of testing

// Pipelines for corn & soybean are 4X & 6X larger than 2012 due to sequencing in the lab

Early Pipeline Yield Testing

// Testing unique genetic combinations with improved characteristics

// Data analytics throughout the pipeline to enhance decision making

Trait Integration

// Corn greenhouse in Arizona scheduled to be online in Spring 2019

// Enabling faster development of new products in a protected greenhouse environment

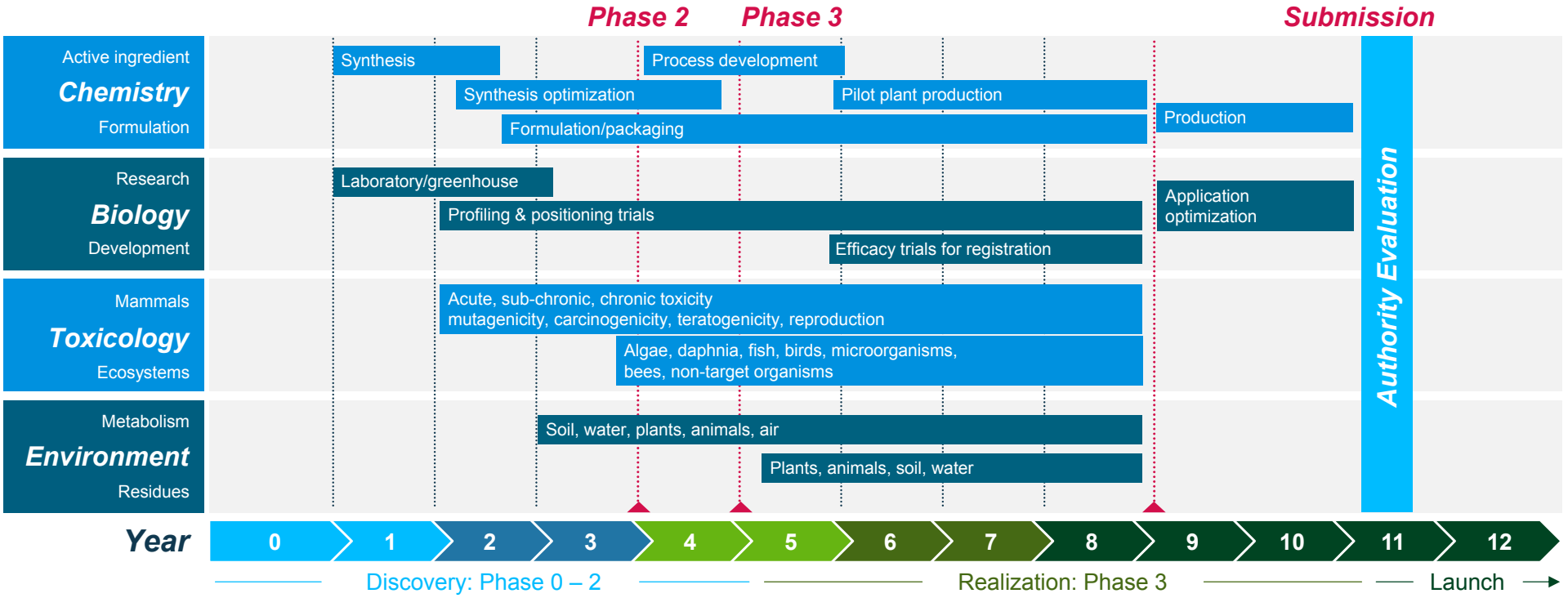
Pre-commercial Yield Testing

// Time savings in the lab enables 2 years of germplasm/trait combination testing in the field

// Improving customer recommendations, better match products to specific environments

8-10 year product development timeline

Chemical Crop Protection – From Idea to Market



After 10 to 14 years and an average investment of about €250m, one compound reaches the market

Glossary of Scientific and Agricultural Terms

Abiotic Stress	The negative impact of non-living factors on the living organisms in a specific environment. The non-living variable must influence the environment beyond its normal range of variation to affect adversely the population performance or individual physiology of the organism in a significant way. Whereas a biotic stress would include such living disturbances as fungi or harmful insects, abiotic stress factors, or stressors, are naturally occurring, often intangible, factors such as intense sunlight or wind that may cause harm to the plants and animals in the area affected. Abiotic stress is essentially unavoidable. Abiotic stress affects animals, but plants are especially dependent on environmental factors, so it is particularly constraining. Abiotic stress is the most harmful factor concerning the growth and productivity of crops worldwide. Research has also shown that abiotic stressors are at their most harmful when they occur together, in combinations of abiotic stress factors.
Agriculture	The art and science of cultivating the ground, including the harvesting of crops and the rearing and management of livestock.
Agronomy	A branch of agriculture dealing with field-crop production and soil management.
Biodiesel	An alternative to standard diesel fuel, this clean-burning, renewable fuel is created by combining methanol or ethanol (the base) with vegetable oil, such as canola or soybean oil, or animal fat.
Biodiversity	(Biological diversity) The variation of taxonomic life forms within a given ecosystem, often cited as a measure of the system's health.
Biofuel	A fuel derived from organic material that is not fossilized like coal or petroleum. Common sources of biofuel are corn, soybean, sugar cane, flaxseed and rapeseed.
Biomass	Organic, nonfossil material available on a renewable basis. Biomass includes all biological organisms, and their metabolic byproducts, that geological processes have not yet transformed into fossilized substances.

Glossary of Scientific and Agricultural Terms

Biotechnology	Applied biological science, as bioengineering or recombinant DNA technology.
Agricultural Biotechnology	An extension of traditional plant breeding through biotechnology, allowing plant breeders to make precise genetic changes that impart beneficial properties to the crop plants that provide food and fiber. Agricultural biotechnology helps farmers increase yields, enabling them to produce more food per acre and it reduces the need for chemicals, pesticides, water, and tilling; thereby providing benefits to the environment as well as to the health and livelihood of farmers. Through specific design, biotechnology also can be used to enhance the nutritive value of staple foods to improve overall nutrition and health.
Biotech Crop	A crop grown from seed that has been modified using biotechnology. Often biotech crops provide benefits through reduced need for plowing soil, reduction in pesticides; and added beneficial crop qualities such as vigor and increased yield.
Bollgard	Trademark for cotton genetically improved to offer protection against common pests, including cotton bollworm, tobacco budworm, and pink bollworm, which can cause significant damage to cotton crops. In-plant pest protection displaces repeated applications of insecticides compared to conventional cotton crops.
Carbon Footprint	The total amount of greenhouse gases emitted, directly and indirectly, by a natural or manmade system, usually expressed in equivalent tons of carbon or carbon dioxide.
Carbon/Climate Neutral	A system with no (or minimal) net carbon footprint. Such systems often pair carbon-producing activities with those that reduce or sequester carbon.
Carbon Sequestration	Any of several processes for the removal of excess carbon dioxide from the atmosphere in an effort to mitigate global warming. Many plants conduct natural biochemical processes that remove carbon from the atmosphere and convert it to biomass. These natural processes can be leveraged in agriculture through conservation tillage.

Glossary of Scientific and Agricultural Terms

Carbon Trading	A trading system modeled on a stock exchange that is designed to offset carbon emissions from one activity (such as burning fossil fuels in manufacturing, driving, or flying) with another (such as installing more efficient technologies, planting carbon-sequestering plants, or establishing contracts with others not to partake in carbon-releasing activities).
Cerrados	The ecologically rich savanna in central Brazil (and some of northeastern Paraguay and eastern Bolivia). Major efforts are underway to preserve this biologically rich savanna.
Climate Change	Any long-term significant change in the “average weather” that a given region experiences. Average weather may include average temperature, precipitation, and wind patterns. Climate change involves changes in the variability or average state of the atmosphere over durations ranging from decades to millions of years. These changes can be caused by dynamic processes on Earth, external forces including variations in sunlight intensity, and more recently by human activities. (See also Global warming)
Corn Borer	(Ostrinia nubilalis) A lepidopteran insect that affects production of maize and other crops, including sorghum, cotton, and many vegetables. It causes damage to the aboveground portions (stalk and ear) of maize plants.
Conservation Tillage	Crop production methods that de-emphasize use of the plow for weed removal and encompass a range of new farming production practices like reduced tillage, or no tillage. In general, these methods all include reduced use of the plow and increased use of crop mulch and cover on the fields. These processes can increase the amount of water in the soil, decreases erosion and increases the amount and variety of soil biota. And they have the potential to aid carbon sequestration by incorporating more plant biomass into the soil.
Conventional Crop	A non-biotech hybrid or inbred crop grown with inputs, such as fertilizer, herbicides, and insecticides.
CSR	(Corporate social responsibility) A business outlook that acknowledges responsibilities to stakeholders – including suppliers, customers, employees, local and international communities in which the organization operates, and the natural environment.

Glossary of Scientific and Agricultural Terms

Detasseling	The act of removing the pollen-producing tassel from a corn (maize) plant and placing it on the ground. By removing the tassels from all plants of one variety, all the grain growing on those plants will be fertilized by the another variety's tassels. In addition to being more physically uniform, hybrid corn produces dramatically higher yields than corn produced by open pollination. With modern seed corn the varieties to hybridize are carefully selected so that the new variety will exhibit specific traits found in the parent plants. The detasseling process typically involves the use of specialized machines and human labor.
Dicamba	(3,6-dichloro-2-methoxybenzoic acid) A herbicide used to control broadleaf weeds. Common herbicides containing dicamba include Clarity Banvel, Oracle and Vanquish.
Ecological Economics	An interdisciplinary framework that seeks to merge the two historically separate fields of economics and ecology. It assumes that an inherent link exists between the health of the Earth's ecosystem and the economic system created by human beings; the economy is a subsystem of the earth's ecological system; and by understanding how each system flows into and out of the other, each can thrive and prosper.
Ecological Footprint	The total ecological impact of a person or system. The amount of land, food, water, and other resources consumed and generated. Usually measured in acres or hectares of productive land.
Ecology	A science that studies the Earth and its systems, including the interrelationships of all living things and all elements of their environment.
Ecosystem	A dynamic and interdependent living community of people, parts or mechanisms that interact with one another.
Feed	A mixture or preparation of food for feeding livestock.

Glossary of Scientific and Agricultural Terms

Fertilizer	Chemical compounds given to plants to promote growth; they are usually applied either through the soil, for uptake by plant roots, or by foliar feeding, for uptake through leaves. Fertilizers can be organic (composed of organic matter), or inorganic (made of simple, inorganic chemicals or minerals). They can be naturally occurring compounds such as peat or mineral deposits, or manufactured through natural processes (such as composting) or chemical processes (such as the Haber process).
Gene Stacked Event	A genetically modified organism (GMO) and all subsequent identical clones resulting from a transformation process are called collectively a transformation event. If more than one gene from another organism has been transferred, the created GMO has stacked genes (or stacked traits), and is called a gene stacked event. Gene stacked events have become an important topic in plant breeding. Occasionally, researchers wish to transfer more than one trait (e.g. an insect resistance and a herbicide resistance) to a crop. Consequently, they need to transfer more than one gene, and do so either in one or in subsequent steps. This can be achieved either by genetic engineering or by conventional cross-breeding of GM plants with two different modifications. In most contexts, the difference between a GMO with one new trait and a GMO with several of these is negligible. However, when the GM content of a harvest or any GM product is being measured, stacked genes may have severe consequences. Many countries require the labelling of GM products if the GM share of a single ingredient exceeds certain limits: for example, this limit lies at 0.9 percent in the European Union. Usually, this is analysed by measuring a genetic sequence common to most GMOs. This sequence is transferred along with the gene of interest, when a new GMO is created. A GMO with more than one transgene contains a corresponding number of copies of this sequence. Therefore, measuring the number of copies of this sequence in a food sample would return a figure twice (or more) as high as the actual GMO percentage. Researchers are trying to develop new measuring techniques to overcome this hurdle. Some of these projects are being conducted under the extensive European research programme on co-existence and traceability of GMOs, Co-Extra.
Genetically Modified Organism	Plants and animals that have had their genetic makeup altered to exhibit traits not intrinsic to the organism. In general, genes are copied from one organism that shows a desired trait and transferred into the genetic code of another organism.

Glossary of Scientific and Agricultural Terms

Genomics	The science that identifies crop traits and accelerate plant breeding. It is one of the tools used to "mine" germplasm, finding the best combinations of characteristics that can be bred or introduced into plants for better products. Genomics allows the "mapping" of a plant's genes to understand its structure and the role it plays in the plant's function.
Germplasm	The basic genetic material for any plant, used to develop new seed varieties. Within the germplasm are the basic characteristics that make plants what they are. A seed's genetic material that does not include the genetically modified organisms contained in a trait.
Global Warming	An aspect of climate change. The increase of temperature in the Earth's atmosphere and oceans. Global warming is accelerated by the greenhouse gases expelled into the atmosphere from manmade sources. (See also climate change.)
Glufosinate	Glufosinate is an active ingredient in several nonselective systemic herbicides - Basta, Rely, Finale, Challenge and Liberty. Glufosinate controls both monocot and dicot weeds.
Glyphosate	A non-selective herbicide used to kill weeds prior to planting and on fields where crops have Roundup Ready technology. It is the primary ingredient in Roundup agricultural herbicides.
Green	A metaphor referring to environmental association. Often used to associate products, organizations, political parties, or policies with environmental sensitivity.
Green Tech	A collection of new technologies and approaches that maximize human, environmental, and economic benefits.
Greenhouse Gas	Gases produced from human activities that trap solar radiation and thus contribute to climate change. These include carbon dioxide (C02), methane (CH3) and hydrofluorocarbons (HFCs).

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Herbicide	A herbicide is used to kill unwanted plants. Selective herbicides kill specific targets while leaving the desired crop relatively unharmed. Some of these act by interfering with the growth of the weed and are often based on plant hormones. Herbicides used to clear waste ground are nonselective and kill all plant material with which they come into contact. Some plants produce natural herbicides, such as the genus Juglans (walnuts). They are applied in total vegetation control (TVC) programs for maintenance of highways and railroads. Smaller quantities are used in forestry, pasture systems, and management of areas set aside as wildlife habitat..
Hybrid	A plant that is heterogeneous; the offspring of two plants of the same species but different varieties.
Hydrogenation	To add hydrogen to the molecules of an unsaturated organic compound. In processing vegetable oils, hydrogenation results in the conversion of liquid vegetable oils to solid or semi-solid fats. Trans fats are a byproduct of this process.
Hypoxic Zone	Hypoxia means “low oxygen”. In estuaries, lakes, and coastal waters, low oxygen usually means a concentration of less than 2 parts per million. For example, the Gulf of Mexico hypoxic zone is an area along the Louisiana-Texas coast where water near the sea floor has hypoxic conditions.
Input	Resources used in agriculture to produce a crop, including seed, fertilizer, herbicide, and insecticide.
Invasive Species	A species of plant, animal, or fungus that tends to spread unaided in a nonnative ecosystem.
Marker Genes	Genes coding for particular traits that allow a microorganism to be tracked.
Metrics Conversion	1 hectare = 2.471044 acres

Glossary of Scientific and Agricultural Terms

Molecular Breeding	An enhanced tool that involves the use of DNA markers for genes in combination with physical measurement of traits to accelerate selection in plant breeding programs. Also called marker-assisted breeding
Mutagenic	An agent, such as a chemical, ultraviolet light, or a radioactive element, that can induce or increase the frequency of mutation in an organism.
Open-Pollinated	Uncontrolled pollination of a crop by insects, birds, wind, or other natural mechanisms. It can result in seeds and plants of varying quality and hardiness.
Organic	In food and agriculture, the term generally describes the absence of chemical pesticides, synthetic hormones and fertilizers, and certain other materials in the cultivation of end products.
Organic Crop	A crop grown without employment of chemically formulated fertilizers, growth stimulants, antibiotics, or pesticides.
Plant Breeding	The process of working with a plant species to create desired characteristics for specific purposes in successive generations. This process involves either controlled pollination, genetic engineering, or both, followed by artificial selection of progeny.
Pesticide	A pesticide is a substance or mixture of substances used to kill a pest. A pesticide may be a chemical substance, biological agent (such as a virus or bacteria), antimicrobial, disinfectant or device used against any pest. Pests include insects, plant pathogens, weeds, mollusks, birds, mammals, fish, nematodes (roundworms) and microbes that compete with humans for food, destroy property, spread or are a vector for disease or cause a nuisance. Although there are benefits to the use of pesticides, there are also drawbacks, such as potential toxicity to humans and other animals.
Renewable	Any material or energy that can be replenished in full without loss or degradation in quality.

Glossary of Scientific and Agricultural Terms

Rootstock	A rootstock is a plant, and sometimes just the stump, which already has an established, healthy root system, used for grafting a cutting or budding from another plant. The tree part being grafted onto the rootstock is usually called the scion. The scion is the plant which has the properties desired by the propagator, and the rootstock is the working part which interacts with the soil to nourish the new plant. After a few years, the tissues of the two parts will have grown together, producing a single tree although genetically it always remains two different plants. The use of rootstocks is most commonly associated with fruiting plants and trees but is the only way to mass propagate many types of plants that do not breed true from seed or are particularly disease susceptible when grown on their own roots. Although grafting has been practiced for many hundreds (if not thousands) of years, most orchard rootstocks in current use were developed in the 20th century
Roundup	A brand of agricultural herbicides produced by Monsanto. The properties of Roundup agricultural herbicides and other glyphosate products can be used as part of environmentally responsible weed control programs, including conservation tillage.
Roundup Ready	A trademark for biotechnology traits that convey in-plant tolerance to glyphosate, enabling growers to spray labeled Roundup branded agricultural herbicides over the top, with excellent crop safety and no yield reduction.
Seed Production	The process of growing crops to be sold as seed, instead of growing crops to sell as food or feed. Because each seed will become a crop plant, seed production requires high standards for quality and germination.
Stewardship	Responsible caretaking of products and resources. In ecology, this means making decisions regarding the care of the environment with the goal of passing healthy ecosystems on to future generations.
Sustainability	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Sustainable Agriculture	Farming methods that allow the production of crops or livestock without damage to the farm as an ecosystem, including effects on soil, water supplies, biodiversity or other surrounding natural resources.

Glossary of Scientific and Agricultural Terms

Sustainable Development	A pattern of resource use that seeks to meet human needs while preserving the natural environment so these needs can be met in the present and in the indefinite future.
Sustainable Management	The ability to direct the course of a company, community, organization, country or any activity that restore and enhance all forms of capital (human, natural, manufactured, and financial) to generate stakeholder value and contribute to the well being of current and future generations.
Subsistence Farmer	A farmer who grows just enough food for his family's own needs with little, if anything, left over to sell.
Trait	An important characteristic of a crop that is determined by a specific gene or set of genes. It generally implies a biotech trait, but not necessarily. A trait is a specific genomic characteristic of a plant variety/hybrid. Non-biotech traits include high oil and waxy corn. Bayer biotech traits include Roundup Ready, Yieldgard Corn Borer, etc.
Trait Combination, Trait Stacking	The combination or "stacking" of traits allows the farmer to have the value of multiple traits, instead of having to choose between them. Combining traits provides tangible cost and yield advantages to farmers. Within each respective crop, farmers can choose to combine different traits in a single seed, including insect-protection and herbicide tolerance. These product offerings are commonly referred to as "stacked" traits.
Transgenic	An organism that has acquired traits from another species, as through biotechnology. Although DNA of another species can be integrated in a plant genome by natural processes, the term "transgenic plants" refers to plants created in a laboratory using recombinant DNA technology. The aim is to design plants with specific characteristics by artificial insertion of genes from other species or sometimes entirely different kingdoms. Varieties containing genes of two distinct plant species are frequently created by classical breeders who deliberately force hybridization between distinct plant species when carrying out interspecific or intergeneric wide crosses with the intention of developing disease

Glossary of Scientific and Agricultural Terms

Transgenic *(continued)*	resistant crop varieties. Classical plant breeders use a number of in vitro techniques such as protoplast fusion, embryo rescue or mutagenesis to generate diversity and produce plants that would not exist in nature. Such traditional techniques (used since about 1930 on) have never been controversial, or been given wide publicity except among professional biologists, and have allowed crop breeders to develop varieties of basic food crop, wheat in particular, which resist devastating plant diseases such as rusts. Hope is one such wheat variety bred by E. S. McFadden with a gene from a wild grass. Hope saved American wheat growers from devastating stem rust outbreaks in the 1930s. Methods used in traditional breeding that generate plants with DNA from two species by non-recombinant methods are widely familiar to professional plant scientists, and serve important roles in securing a sustainable future for agriculture by protecting crops from pests and helping land and water to be used more efficiently.
Vistive	A Bayer brand of soybean and oilseed rape designed to produce better oils that help meet consumer demand for healthy, great-tasting foods. These oilseeds contain lower levels of linolenic acid, resulting in more stable oil with less need for hydrogenation. The hydrogenation process of soybean produces undesirable trans fats.
YieldGard	A trademark for biotechnology traits for maize genetically modified to protect against specific lepidopteran pests, such as corn rootworm, corn borer, and others.
Zero Waste	The goal of developing products and services, managing their use and deployment, and creating recycling systems and markets to eliminate the volume and toxicity of waste and materials, and to conserve and recover all resources.