



Science for a Better Life

# re generating growth



## Designer Seeds: Next-Generation Breeding Technology

Crop Science Innovation Summit

June 20, 2023

**Mike Graham** // Head of Plant Breeding, Bayer Crop Science





# Cautionary Statements Regarding Forward-Looking Information



**This presentation may contain forward-looking statements based on current assumptions and forecasts made by Bayer management**

Various known and unknown risks, uncertainties and other factors could lead to material differences between the actual future results, financial situation, development or performance of the company and the estimates given here. These factors include those discussed in Bayer's public reports which are available on the Bayer website

▶ [WWW.BAYER.COM](http://WWW.BAYER.COM)



**The company assumes no liability whatsoever to update these forward-looking statements or to conform them to future events or developments**



# Bayer Plant Breeding Unmatched Scale Maximizes Farm Productivity

> Bayer Plant Breeding products reach ~160m acres globally

Six main row crops:



Corn



Soybean



Cotton



OSR/ Canola



Wheat



Rice



Elite germplasm with integrated biotech and native traits deliver **€10.5bn** annual seed & trait sales

## > Delivering World-Class Genetics and Product Offerings



Increasing Yield Potential



- > Developing and deploying **>500** unique products every year across large and small holder **customers**
- > Enabling increased **yield potential** across crops



Managing Biotech and Native Breeding Traits



- > Managing **~65 active biotech and native traits and 138 trait packages** across crops within the breeding pipeline
- > **Native traits** like Short Corn (SD) and disease resistance provide additional value



Building Next Generation Innovations

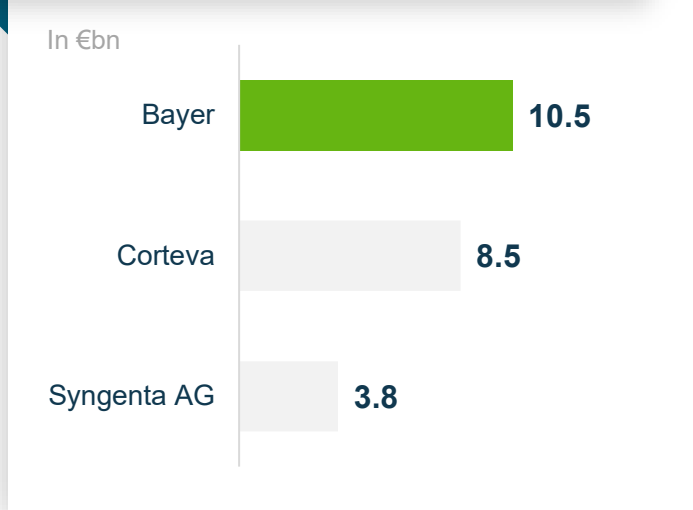


- > Each product advanced through the breeding pipeline goes through **~140 data science models** until commercialized
- > New **protected culture** facilities in Marana, AZ and Petrolina, Brazil, expected to **accelerate breeding** generations by **up to 6X**

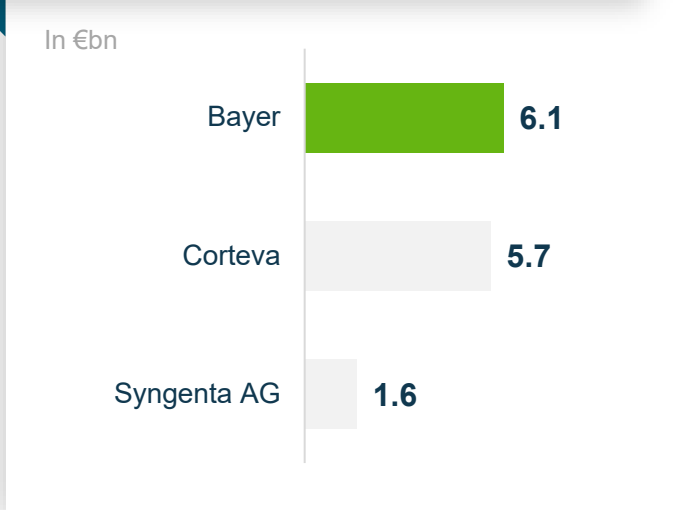


# Leading Positions in Global Seed & Traits Fueled by Innovation

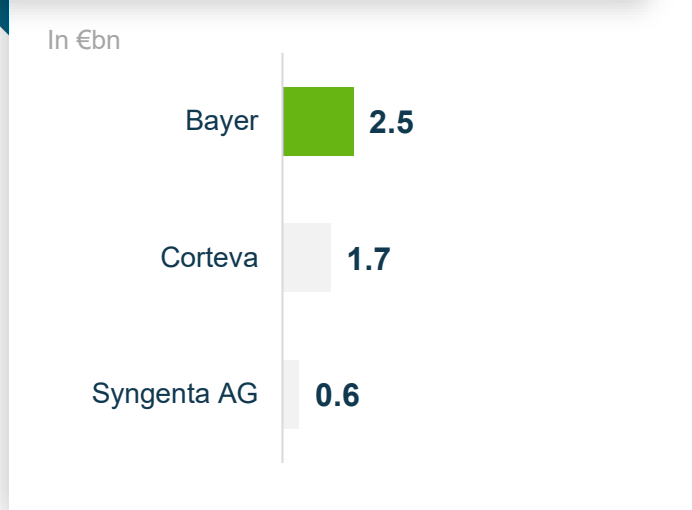
## > 2022 Global S&T Sales<sup>1</sup>



## > 2022 Corn S&T Sales<sup>1</sup>



## > 2022 Soy S&T Sales<sup>1</sup>



**#1 | Market Position<sup>2</sup>**  
 Corn Seed & Traits  
 Soybean Seed & Traits  
 U.S. Cotton Seed & Traits  
 Wheat Germplasm- U.S.

**#2 | Market Position<sup>2</sup>**  
 Vegetable Seed

Seed Share<sup>3</sup>

Region	Seed Share <sup>3</sup>
U.S.	>55%
Brazil	~30%
Argentina	~50%
Europe	~20%
South Africa	~70%

Seed Share<sup>3</sup>

Region	Seed Share <sup>3</sup>
U.S.	>35%
Brazil	~20%

<sup>1</sup> Source: As reported in FY 2022, exchange rate FY2022: ~1.05 USD/EUR. <sup>2</sup> Market Position determined annually, as of Q1-2022. <sup>3</sup> Internal estimate including sum of branded plus licensed seed (germplasm) share measured as of 2022 for U.S. and Europe and as of 21/22 season for Brazil, Argentina and South Africa

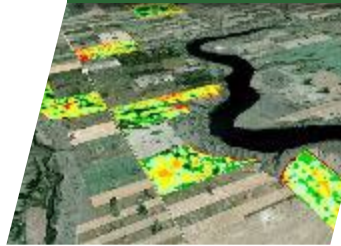


# Data Connected Plant Breeding Advantage



## Breeding Product Development Process (8-10 years)

Data & analytics driving decisions & AI connected pipeline - enabling a dynamic breeding pipeline



Fieldview Field Health Imagery Data Collection



Seed Chipping Technology for accelerated discovery



Marana, AZ Protected Culture Design Center



Cassette Planter delivers large scale field testing



Drone Sensors; globally connected data ecosystem



Seed Bulk-Up for Pre-Launch testing

### Customer Insights

#### Data & Insights

Customer driven quantitative economic indices

### Discovery

#### Population Selection

Population simulation and human supervised, model driven selection for desired characteristics

### Phase One

#### Early Design

Advanced genomic selection including future environmental challenges

### Phase Two

#### Intermediate Development

Large-Scale Field Testing, Trait Integration and prescriptive data collection to inform models and feed pipeline

### Phase Three

#### Advanced Product Understanding

Traited Testing, Early Tailored Solutions data generation, and preparation of digital data package for Climate models

### Phase Four

#### Pre-Launch

Broad product testing by R&D and Market Development, Seed Bulk-Up, System Testing and Pre-Marketing

## Competitive Advantages

- › Extensive environmental and on-farm data driving targeted discovery
- › Unique data-driven bio-economic models that allow precise fitting of product concepts

- › Industry-leading global germplasm libraries across crops and markets- 100X larger
- › Decades of field and genomic data combined with industries leading data science platform

- › Ability to rapidly sample and genetically evaluate millions of seeds- 15X faster
- › Advanced Product Design facilities that enable multiple cycles of planting per year

- › Industry leading Trait Integration programs stack traits into elite germplasm
- › Largest global field-testing footprint & digital field-testing twin capabilities diversifies geographic data insights

- › Fully automated seed distribution centers prescriptively sample diverse growing environment
- › Traited-Testing evaluates products as they would be experienced by the growers

- › Most advanced and distributed network of field testing in the industry
- › Evaluation of agronomic systems for product deployment & customer recommendations





# Deploying >250 Corn Hybrids in 2022 to Expand Leading Position

Foundational to Expected Growth in Our >€6bn Global Annual Corn Seed & Trait Sales

## Extensive Corn Germplasm Delivers



- > **>100m** acres of Bayer Corn Germplasm grown in 2022
- > Deployed **>250** new hybrids globally in 2022; offer **>1,500** hybrids globally
- > **>7 bu/acre U.S. yield advantage** with leading hybrids in like-for-like trait package hybrid comparisons<sup>1</sup>
- > **Best NCGA Yield Performer<sup>2</sup>** in 2022, winning **>70%** of the **~National Spots**, with 20 of the 27 spots from Bayer germplasm



## Key Seed Brands



<sup>1</sup> Annual yield advantage calculated each year by comparing 3 leading DEKALB products within each state having a minimum of 100 comparisons to national competitor products containing similar crop protection traits as of 2022. All comparisons are head-to-head using +/- 2RMs and weighted average calculated using 15% moisture; <sup>2</sup> NCGA = National Corn Growers Association – National Corn Yield Contest.



# Soybeans, Cotton and Vegetable Seed Businesses Benefit from Annual Germplasm Refresh to Drive Sales Growth



## Soybeans

- > Deployed **~150** new varieties in 2022; offer **>850** varieties in North America
- > Over last 4 years, RR2Xtend & Xtend Flex Soybeans saw a **2.9 bu/acre advantage<sup>1</sup>** over Enlist™ E3 Soybeans



## Cotton

- > Deployed **>10 varieties** in 2022; offer **>30 Deltapine varieties in the U.S.**
- > U.S. lint/acre yield advantage with leading varieties; 2022 was **~70 lbs/ac advantage for Deltapine<sup>2</sup>** vs. top-planted competitor varieties



## Vegetables

- > Deployed **>90** varieties in 2022; sell **~2,000 vegetable hybrids** and varieties in **22 crops** across **110 countries**
- > Innovative varieties of fruits and vegetables can **help develop more sustainable and regenerative food systems** and increase access to essential nutrients

<sup>1</sup> Soy Trials: (184 locations with 20 in 2019 (Roundup Ready® 2 Xtend), 57 in 2020 (Roundup Ready® 2 Xtend), 67 in 2021 (XtendFlex® Soybeans) and 40 in 2022 (XtendFlex® Soybeans) reporting data located with 22-IA, 24-IL, 23-IN, 11-KS, 1-KY, 7-MI, 30-MN, 10-MO, 1-MS, 5-ND, 17-NE, 15-OH, 1-OK, 11-SD, 4-PA and 2-WI, ). Significant at P ≤ 0.10 LSD at 0.6 Bu/A as of 12/13/2022. Roundup Ready 2 Xtend or XtendFlex® soybeans planted with a farmer-selected (or in case of Bayer Trials, Bayer-selected) weed control program that may include dicamba, glyphosate, glufosinate and various residual herbicides. Enlist E3® soybeans planted with a farmer-selected (or in case of Bayer Trials, Bayer-selected) weed control program that may include glyphosate, Enlist One® herbicide, Liberty® 280 SL herbicide and various residual herbicides; <sup>2</sup> Cotton 3-year average: 2600 trials comparing top DP varieties within a region vs. the top 3 planted competitors based on market survey data (Kynetec).



# Breeding Pipeline to Deliver €11bn in Peak Sales Potential

Thousands of New Varieties and Hybrids in Development to Fuel Growth in €10.5bn S&T Sales

## Other: ~€1bn

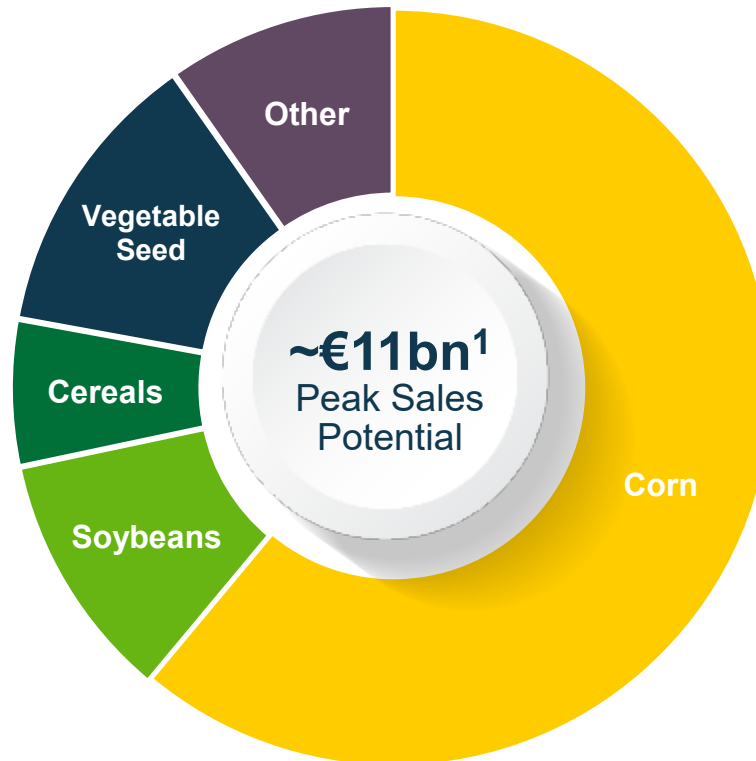
- Rice hybrids for APAC
- Hundreds of Cotton varieties to support annual refresh in U.S.; ~10/year
- Canola germplasm for EMEA and Canada

## Vegetable Seed: ~€1bn

- Thousands of new varieties in over 22 different crops; ~ 90/year

## Cereals: ~€1bn

- Hybrid Wheat
- Wheat Germplasm and Disease Pkg.



## Corn: ~€7bn

- Thousands of new corn hybrids in development for annual refresh across each global market; ~ 250/ year
- Corn Disease Shield- NA

## Soybeans: ~€1bn

- Thousands of new soy varieties in development for annual refresh across Americas ~150/ year
- Soybean Native Resistance

*Upside potential from Direct Seeded Rice System*

<sup>1</sup> Represents non-risk adjusted estimated peak sales for the breeding pipeline. ~50% incremental sales value. Note: Projects listed per crop are subset of the pipeline; selected top contributors to peak sale potential



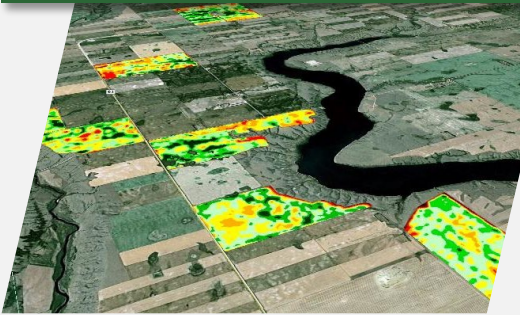


# Accelerating Genetic Gain with Precision Breeding



**ACCELERATING OUR ABILITY** to bring innovative solutions to our customer around the world

Data & analytics driving decisions & AI connected pipeline - enabling a dynamic breeding pipeline



Fieldview Field Health Imagery Data Collection



## Customer Insights

Customer Driven quantitative economic indices



Seed Chipping Technology for Accelerated Discovery



## Advanced Genomic Capabilities

Genomic Insights & AI driving new breeding starts



Marana, AZ Protected Culture Design Center



## Accelerated Breeding Methods

Genomic Insights & AI driving new breeding starts



Cassette Planter delivers large scale field testing



## Digital Field-Testing Twin

Mix of simulated and actual field testing

**Doubling Genetic Gain by 2030**

**Accelerating Breeding Cycle from 5-6 years to ~4 months**



# Data Driven Solutions and Simulation Key to Acceleration

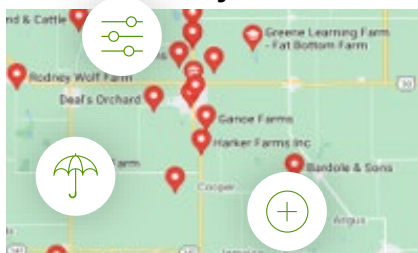
## > Starts with a Customer Driven Pipeline

- > Every plant designed is aligned with **customer-preference quantification**
- > Novel translation of **customer insights into a number** allowing for accurate data driven decisions through product development
- > Selection indices combine **economic and agronomic** data with customer survey preferences and insights to determine desired characteristics for next-gen. hybrids

Greene County, Iowa Customer Survey Preferences

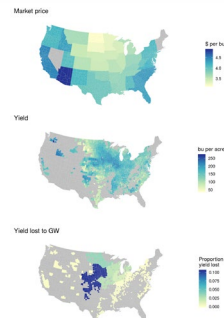
Economic, Yield and Disease Pressure Data

### Standability



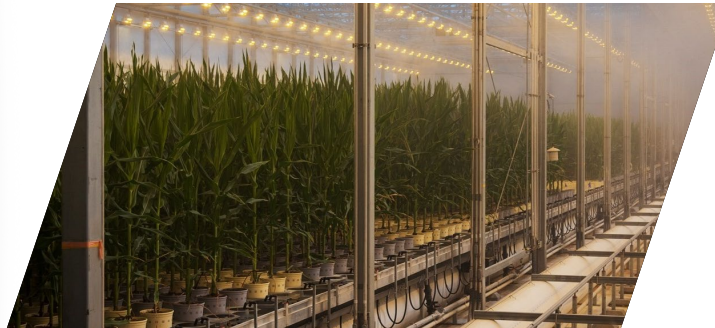
Drydown

Robustness



## > Accelerated Breeding Methods

- > Continuous Breeding Cycle **accelerating from 5-6 years to ~4 months**
- > New **protected culture** facilities in Marana, AZ and Petrolina, Brazil,

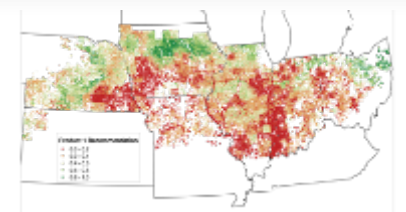


## > Leads to Digital Field-Testing Twin

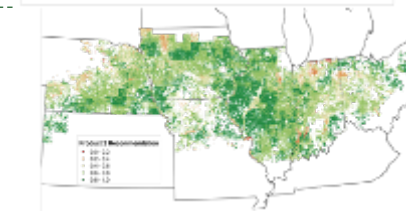
- > Simulations use our **extensive data assets** to predict performance across millions of scenarios and environments
- > Simulations assist with **crop placement** and **product advancement**

### Example: PRECEON Hybrid Ear Height Simulation

**Short-Stature Hybrid1** - Ear height too low in simulation



**Short-Stature Hybrid 2** - shows favorable ear height in simulation



**Simulated ear height for >130k farmer fields across 10 environmental years**



# Hybrid Wheat: New Production System for the World's Largest Crop

Potential to Shape Transformation of Wheat Production by End of the Decade

## Resilient Hybrid Wheat System

- Hybrid wheat expected to provide **higher yield** and **yield stability**, with potential fit on a significant portion of the **~555m acres of wheat** grown globally and **~€700m PSP**
- Envision a **more sustainable and resilient system** with better nitrogen use efficiency, disease, drought and heat tolerance
- Advancements in **genomic tools** and the **cytoplasmic male sterility system** are enabling the development of hybrid wheat at competitive cost
- 'Blue ocean' market potential to drive value of market for Wheat seed and technologies, which has already happened in crops like corn



Hybrid Wheat Row Configuration Testing  
Nampa, Idaho | June 2022



Hybrid Wheat Nursery  
Filer, Idaho | June 2022

## Market Leaders in Hybrid Wheat

Different climatic zones in key regions Europe and North America require **distinct approaches**:

### Europe

- In 2021, we launched a **strategic R&D partnership with RAGT**, the European market leader in varietal wheat, leveraging strong complementarity of partners:
  - RAGT**: Best-in-class germplasm and rich portfolio of native traits
  - Bayer**: Wide array of R&D assets, seed production know-how; leader in CP

### US

- Hybrid wheat program based on our leading U.S. WestBred germplasm position



**Our Vision:**

A digitally enabled sustainable hybrid wheat system offering





# Direct Seeded Rice: More Sustainable & Profitable Solution

## Rice Production Systems Today Water & Labor Intensive

- > 3<sup>RD</sup> LARGEST GLOBAL CROP WITH 165M HA<sup>1</sup>
- > USES UP TO 43% WORLD'S IRRIGATION<sup>2</sup>
- > ~80% TRANSPLANTED PRODUCTION<sup>3</sup>

<sup>1</sup> Our World in Data: [Land area per crop type, World, 1961 to 2021 \(ourworldindata.org\)](https://ourworldindata.org/land-area-per-crop-type-world-1961-to-2021)  
<sup>2</sup> International Rice Research Institute: [Water management - IRRI Rice Knowledge Bank](https://www.irri.org/knowledge-bank/water-management)  
<sup>3</sup> Scientific Reports: [A global analysis of alternative tillage and crop establishment practices for economically and environmentally efficient rice production | Scientific Reports \(nature.com\)](https://www.nature.com/articles/s41598-020-78111-2)

## FARMER ECONOMICS SHOW 16% LOWER COSTS WITH DSR<sup>4</sup>

- > Reduces Water Usage by up to 40%<sup>5</sup>
- > Up to 45% reduction in CO2 emissions<sup>6</sup>
- > Manual labor reduced by up to 50% or 150 labor hours per 1 Ha DSR<sup>7</sup>
- > Methane reduction up to 85%<sup>8</sup>

<sup>4</sup> Internal estimate via DirectAcre program in India | <sup>5</sup> TRP Water Use: Kyenotec Panel Survey Data 2020, IRRI (2009), Bouman et al. (2002) | Water Savings from TRP to DSR: Bayer Sustainable Rice Initiative Pilot, Singh et al. (2015) | <sup>6</sup> Carbon emission - IPCC (2006/2019) | <sup>7</sup> Labor: Sidana et al. (2020) | <sup>8</sup> CH4 Reduction: Science Direct [Direct-seeded rice reduces methane emissions - ScienceDirect](https://www.sciencedirect.com/science/article/abs/S0926661120300000)

## Today: Resource Intensive Transplanted Rice (TPR) practices



Puddling & Leveling



Nursery Beds



Manual transplanting



Manual reaping

## Future: Mechanized and Technology driven Direct Seeded Rice (DSR) cultivation



Laser land levelling



Direct seeding with machinery



Precision Application



Mechanical harvesting



**Our Target:**

Improve water use per kg of crop by 25% in 2030 by transforming rice cropping system



# Bayer Direct Acres: DSR Crop System Featuring Hybrid Rice

Elite Rice Germplasm, Effective Weed Mgmt. and Digital Tools to Drive Sustainable, Operational Efficiency

## Seeds & Seed Growth

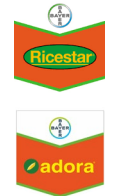


~40% Seed Share in DSR Market in India (7% of Acres)

## Herbicides



Post-Emergent single shot application



Need Based LPO

## Fungicides



## Insecticide



## Crop Performance Enhancer



Bayer **direct acres**

Bayer Portfolio of Solutions for Rice Production

## DIGITAL TOOLS & PLATFORMS



## CARBON & SUSTAINABILITY

Opportunity for **75%** DSR HA in India by 2040<sup>1</sup>

**DIRECT SEEDED RICE SYSTEM**

- > Elite Designed Hybrid Rice // // // //
- > Integrated & Effective Weed Mgmt System // // // //
- > Digital Insights & Agronomic Support // // // //

## HYBRID RICE TRIALS



<sup>1</sup> internal estimate based on socio economic, climate effects and policy environment



# Key Takeaways – Designer Seeds

- 01** Foundational germplasm platform delivers **~500 new products annually on >160m acres**
- 02** Delivers **~€11bn in peak sales potential** with expansion and upside potential
- 03** Widening our leadership position through **AI connected pipeline** and **key investments** to improve genetic gain and acceleration to market
- 04** Enabling opportunities in underserved market, like **hybrid wheat and direct seeded rice**
- 05** **Driving regenerative ag** with higher farm productivity, as well as resource and water utilization







Science for a Better Life

APPENDIX

# re generating growth



## Designer Seeds: Next-Generation Breeding Technology

Crop Science Innovation Summit

June 20, 2023

**Mike Graham** // Head of Plant Breeding, Bayer Crop Science





# Crop Science: Seed & Traits and Digital R&D Pipeline

(Annual Update Feb 2023)

€21bn  
PSP

	Phase I	Phase II	Phase III	Phase IV	PSP
CORN SEED & TRAIT	Corn Disease Shield - NA	5th Generation Lepidoptera Protection 5th Generation Herbicide Tolerance w/ (RHS2) <b>Digital Disease Mgmt. – NA</b> <b>Seed Placement Digital Tool - NA</b>	Short Stature Corn – Biotech Trait <sup>3</sup> 4th Generation Coleoptera Protection	Short Stature Corn – Breeding Approach 4th Generation Lepidoptera Protection <b>Seed Density Digital Tool – EMEA</b> <b>Seed Density Digital Tool – LATAM</b>	~€11bn
	Annual Germplasm Upgrades	Annual Germplasm Upgrades	Annual Germplasm Upgrades	Annual Germplasm Upgrades	
	Digital Disease Mgmt. - NA	Seed Placement Digital Tool – NA <b>4th Generation Insect Protection</b>	3rd Generation Insect Protection 2nd Generation Soy Cyst Nematode resistance 4th Generation Herbicide Tolerance (HT4) (5 Tolerances – Adds 2, 4-D and HPPD) <b>5th Generation Herbicide Tolerance (6 Tolerances – Adds PPO)</b>	Vistive Gold Xtend	
Annual Germplasm Upgrades Soybean Native Resistance	Annual Germplasm Upgrades Soybean Native Resistance	Annual Germplasm Upgrades Soybean Native Resistance	Annual Germplasm Upgrades Soybean Native Resistance		
Canola/OSR Digital Disease Mgmt. - NA	Wheat Digital Disease Mgmt. - EMEA	Canola Dicamba Tolerance Sugarbeets 2nd Generation Herbicide Tolerance <sup>2</sup> Cotton 4th Generation Herbicide Tolerance (HT4) (5 tolerances – Adds 2, HPPD and PPO) Cotton 4th Generation Insect Protection	Lygus and Thrips Control (ThryvOn Technology) - <b>Stewarded Commercial Launch</b>	~€6bn	
Wheat Annual Germplasm Upgrades	Wheat Annual Germplasm Upgrades	Wheat Annual Germplasm Upgrades	Wheat Annual Germplasm Upgrades		
Wheat Disease Package Upgrades	Wheat Disease Package Upgrades	Wheat Disease Package Upgrades	Wheat Disease Package Upgrades		
Cotton Annual Germplasm Upgrades	Cotton Annual Germplasm Upgrades	Cotton Annual Germplasm Upgrades	Cotton Annual Germplasm Upgrades		
Canola/OSR Annual Germplasm Upgrades	Canola/OSR Annual Germplasm Upgrades	Canola/OSR Annual Germplasm Upgrades	Canola/OSR Annual Germplasm Upgrades		
Veg- Annual Germplasm Upgrades	Veg- Annual Germplasm Upgrades	Veg- Annual Germplasm Upgrades	Veg- Annual Germplasm Upgrades		
Rice Annual Germplasm Upgrades	Rice Annual Germplasm Upgrades	Rice Annual Germplasm Upgrades	Rice Annual Germplasm Upgrades		

Breeding  
 Trait  
 Digital Model  
 advanced to next phase

Projects listed here and included in the peak sales potential by segment do not include projects funded by our LEAPS investments; includes all advancements made in FY'22, updated Feb'23  
PSP = Peak Sales Potential, 50% incremental; Expected to reach 30% of PSP by 2032, 80% of PSP by 2037 and remainder in 2038+; **Note that products are excluded from the pipeline PSP typically the year following launch**  
<sup>2</sup> In collaboration with KWS; <sup>3</sup> In collaboration with BASF; <sup>4</sup> "Other" category includes seeds and traits, such as cotton, canola, wheat, OSR, rice, vegetable seeds and sugarbeets, plus carbon and digital Models